Journal of Agricultural, Environmental and Veterinary Sciences
Volume (4), Issue (2) : 30 June 2020
P: 99 - 108

AJSRP
ISSN: 2522-3364

مجلة العلوم الزراعية والبيئية والبيطرية
المجلد (4)، العدد (2) : 30 يونيو 2020م
ص: 99 - 108

Effect of water ballast levels in the rear tires on tractor performance using disc plow on heavy clay soil

Omar Alnoor Ali Mohammed Zain
Faculty of Engineering || Sinnar University || Sudan

Abstract: This experiment was carried out at Masaad Center Farm for Technology Transfer and Training in Al-gezira State in Sudan on heavy clay soil with a moisture content of 15.41%. To evaluate the effect of three levels of water ballast in the re ar tires 25%, 50% and 75% and the effect of three different plowing depths 10, 15 and 20 cm with pressure constant (25 psi) in the rear tires. It was linked with disc plow of three discs. The split plot was used with three replications according to Randomized Block Design (RBD). The results were statistically analyzed by using SPSS software. Rolling resistance force, draft force and fuel consumption were highly significantly affected (on 1% level) by the addition of different water ballast levels and tillage depth. The slippage ratio decreased by 15% when increasing the level of water ballast from 25% to 75% at a depth of tillage 15 cm. The rolling resistance increased by 43%, when increasing the water ballast levels from 25% to 75% at a depth of 20 cm. The water ballast levels increased from 25% to 75% at the depth of 10 cm the draft force was increased by 22%. Fuel consumption increased by 26%, when increasing the water ballast levels from 25% to 75% at the depth of tillage of 20 cm. The study showed that the addition of 75% water ballast level in the rear tires improves the performance of the tractor. The study showed that when the water ballast levels increased the fuel consumption, rolling resistance force and draft force were increased and slippage was decreased. As depth of tillage increased, the slippage, fuel consumption, rolling resistance force and draft force were increased.

Keywords: water ballast levels, draft force, slippage, fuel consumption.

تأثير مستويات وزن الماء في العجلات الخلفية على أداء الجرار باستخدام المحراث القرصي في أرض طينية ثقيلة

عمر النور علي محمد زين
كلية الهندسة || جامعة سنار || السودان

الملخص: نفذت هذه التجربة في مزرعة مركز مساعد لنقل التقانة والتدريب بولاية الجزيرة في دولة السودان على تربة طينية ثقيلة ذات نسبة رطوبة 15.41% بغرض تقييم تأثير ثلاثة مستويات من وزن الماء في العجلات الخلفية للجرار25%، 50%و 75%. وثلاثة أعماق مختلفة للحراثة15، 10 و 20سم مع ثبات الضغط في العجلات الخلفية (25 psi)، على الأداء الحقلي للجرار قدرته (80) حصان عند شبكه مع محراث قرصي ذو ثلاثة أقراص. أستخدم في هذه التجربة تصميم القطع المنشقة باستخدام القطاعات العشوائية الكاملة بثلاثة مكررات. واستخدم برنامج (SPSS) للتحليل الإحصائي. النتائج المتحصل عليها تضمنت وجود فروقات معنوية بمستوى معنوية1% في كل من مقاومة التدحرج، قوة السحب واستهلاك الوقود عند إضافة مستويات مختلفة من وزن الماء وعمق الحراثة . حيث انخفضت نسبة الانزلاق بنسبة% 15عند زيادة مستوى وزن الماء من 25%إلى 75% عند عمق الحراثة 15 سم. عندما كان مستوى وزن الماء 75% زادت مقاومة التدحرج بنسبة 43%عند زيادة مستوى وزن الماء من25% إلى 75% عند عمق الحراثة 20سم. وعند زيادة مستوى وزن الماء من25% إلى75%مع عمق حراثة 20سم ازدادت قوة السحب بنسبة 22%.أوضحت الدراسة أن استهلاك الوقود زاد بنسبة26%عند زيادة مستوى وزن الماء من 25%

إلى75%، عند عمق الحراثة 20 سم. وأوضحت الدراسة أن أفضل مستوى لوزن الماء في العجلات الخلفية هو75% مما يؤدى إلى تحسين الأداء الحقلي للجرار. وبينت الدراسة عند زيادة مستويات وزن الماء في العجلات الخلفية للجرار أدى إلى زيادة استهلاك الوقود وقوة السحب ومقاومة التدحرج وانخفاض في نسبة الانزلاق. وكلما زاد عمق الحراثة زاد كل من استهلاك الوقود ونسبة الانزلاق ومقاومة التدحرج وقوة السحب.

الكلمات المفتاحية: مستويات وزن الماء، قوة السحب، الانزلاق، استهلاك الوقود.

1- Introduction

Optimizing the tractor performance in the field depends on the proper matching of the tractor and the implements, which could help in minimizing the fuel consumption and energy loss. Agricultural tractor efficiency relays on better tractive effort which can result from increasing the area of contact between the tractor wheels and the soil surface, and reducing the amounts of fuel used and consequently allows covering more lands in a certain time. Bauer et al, (2013) report that, increasing the weight of the tractor or using additional ballasts also increases the rolling resistance and fuel consumption increasing, the tractor's weight is also reflected in its slip, in addition to the drawbar pull. Increasing the soil moisture content and tillage depth increase wheel slippage and fuel consumption due to decreased the tractive efficiency Moitzi et al, (2014) and Tayel et al, (2015).

The tractive efficiency of tractor could be improved ballasting .Ballasting will be increases the overall weight of the tractor and the area of contact between the soil and the tires and thereby reducing slippage. Ballasting a tractor is usually accomplished by one or more of the following methods: adding wheel weights and filling the tires with water. Increasing the load of tractor drive wheel will increase the shear strength of the soil and therefore increases gross traction. According to Monteiro et al, (2011) for different models of tractors, the average efficiency on the drawbar may vary depending on the relationship between the weight of the tractor and the engine power. Masiero (2010) noted that in different soil surfaces, the maximum average efficiency of the drawbar power varied depending on the model, tractor power and the relationship between the weight and the engine power. The concept of Wheel slippage in tractors has always been one of the main efficient factors affecting fuel consumption by tractors, for both on-field and off field farm operations. Tractor performance is influenced by traction element, soil condition, implement type, and tractor configuration Brixius, W. W. (1987).

Qaisrani et al, (1992) reported that proper ballasting reduced wheel slip, fuel consumption, tire wear and cost of tractor operation, they observed wheel slip reduction and fuel saving up to 33% and 26% respectively with proper ballasting. Implement hitch system was influenced by the size of implement and tractor, and the type of implement. With regard to hitching, the implement may be trailed, fully mounted or semi mounted. the trailed implements always have means for supporting their weights and small vertical forces this type of hitching has the best effect of the dynamic load provided the tractor rear wheels Maali(2010).

2- Material and method

This experiment was carried out at Masaad Center Farm for Technology Transfer and Training in (Al-gezira State, Sudan) on heavy clay soil with a moisture content of 15.41%. To evaluate the effect of three levels of water ballast in the rear tires 25%, 50% and 75% and the effect of three different plowing depths 10, 15 and 20 cm with pressure constant (25 psi) in the rear tires. It was linked with disc plow of three discs. The split plot was used with three replications according to randomized block design (RBD). The results were statistically analyzed by using SPSS software.

Materials:

- Tractors: Two tractors were used in experiment as show specifications in Table (1)
- Disc plow: Primary tillage implements, it's fully mounted, made in turkey; with three disc blades and three unites the disc angle was 45°with the tilt angle 20°.
- Dynamometer: Mechanical dynamometer spring (100 kN capacity) using for measuring draft force after connecting it's between two tractors.
- Metallic ruler: For measuring depth of cut
- Measuring tape: A measuring tape, 50 m long was used for measuring the dimensions and distances.
- Steel pegs: Were used for marking the distances during the experiment.
- Steel chain: Used to pull the tested tractors by the auxiliary tractors.
- Stop watch: It was used for determining the time periods required during the experiment.
- Graduate cylinder: It was one liter in volume, and was used to refill the tractor fuel tank, to determine fuel consumption in each operation.
- Fuel container: Was used to keep the diesel fuel in the field for refilling the fuel tank after operations.

Table (1) Specifications of tractor.

Total weight	2630 kN
Rear axle weight	1709.5 kN
Front axle weight	920.5 kN
Type of tractor	New Holland – ITALY
Model	80-66S
Engine	4stroke 4cylinder 80hp
Distance between axle	150 cm
Number of wheel drives	2WD
Tire (Front-rear) Tire width (Front-Rear)	(7.5-16)(13.6-38) (15-32) cm
Overall width	180 cm
Overall length	351 cm

Total weight	2630 kN
Wheel base Rear tire max load	230.5 cm 1950 kg (4300 Lbs)
Max inflation pressure	2.0 bar (29 psi)

Methods:

- How to maintain the water levels in the tractor tires:

Divide the tire to four part then start filling the parts then start filling the part with water to 25%, 50% and 75% levels through the air valve.

- The tractor slippage at different water ballast levels and depths was calculated by using the following equation as stated by Elani (1994):

$S\% = [(V_t - V_f) / V_t] \times 100$ (2-1)

Where:

S% = slippage ratio. V_f = field speed (km/h). V_t = theoretical speed (km/ h).

- Measurement of draft was done as follows:

Mechanical dynamometer spring was linked to the front of the tested tractor with the implement was linked.

An auxiliary tractor was linked to the tested one through the dynamometer with steel chain. The auxiliary tractor pulled the tested tractor while the latter was positioned in the neutral state, but with the implement unloaded, in the idle position. The draft was recorded for a measured distance of 50m. Then the implement was put in operation position (loaded), and the rear tractor was pulled to record the draft force. The difference between the two readings gives the value of the draft of the implement as stated by Naderloo *et al,* (2009).

Draft was calculated as follows:

Implement draft (kN) = Draft of implement loaded – draft of implement unloaded ...(2-2)

- Measurement of Fuel Consumption (Q):

$$\text{Fuel rate (L/hr)} = \frac{(\text{Reading of cylinder (mL)} / 1000) \ast 3600}{\text{Time required to cover the plot}} \quad (2\text{-}3)$$

3- Results and discussion

Effect of water ballast levels and depths on the slippage

Table (2) and Figure (1) present the values of rear wheel slippage implement at different water ballast levels and depths. The effect of water ballast levels and depths on the slippage showed no significant differences. The result illustrates that, the mean values of slippage of water ballast level 25%

were 11.82%, 12.63% and 13.27% at depths 10 cm, 15 cm and 20 cm respectively. The average values of slippage of water ballast level 50% were 10.71%, 11.18% and 12.26%, at depths 10 cm, 15 cm and 20 cm respectively. The mean values of slippage of water ballast level 75% were 10.03%, 10.75% and 11.54% at depths 10 cm, 15 cm and 20 cm respectively.

The water ballast level 25% recorded the highest values of slippage compared with the other water ballast levels at three depths. The lowest value of slippage was recorded by water ballast level 75% at depth 10 cm.

At (25%) water ballast level, slippage was increased 10% when the depth of tillage increased from 10 cm to 20 cm. At 50% water ballast level, slippage was increased 13% when the depth of tillage increased from 10 cm to 20 cm. At 75% water ballast level, slippage was increased 13% when the depth of tillage increased from 10 cm to 20 cm. Increasing the water ballast levels from 25% to 75% at a depth of 20 cm the slippage was decreased by 26.4%. This decrease in the slippage is due to the water ballast levels increased and increased wheel soil area of contact and improvement in the adherence effort. The result in agreement with found by Qaisrani *et al.* (1992). Slippage will be decreased with increasing the water ballast levels in agreement with Abboude. (2001). Slippage was increased with increasing the depth in agreement with Abdallah, (2008) and Tayel *et al.* (2015).

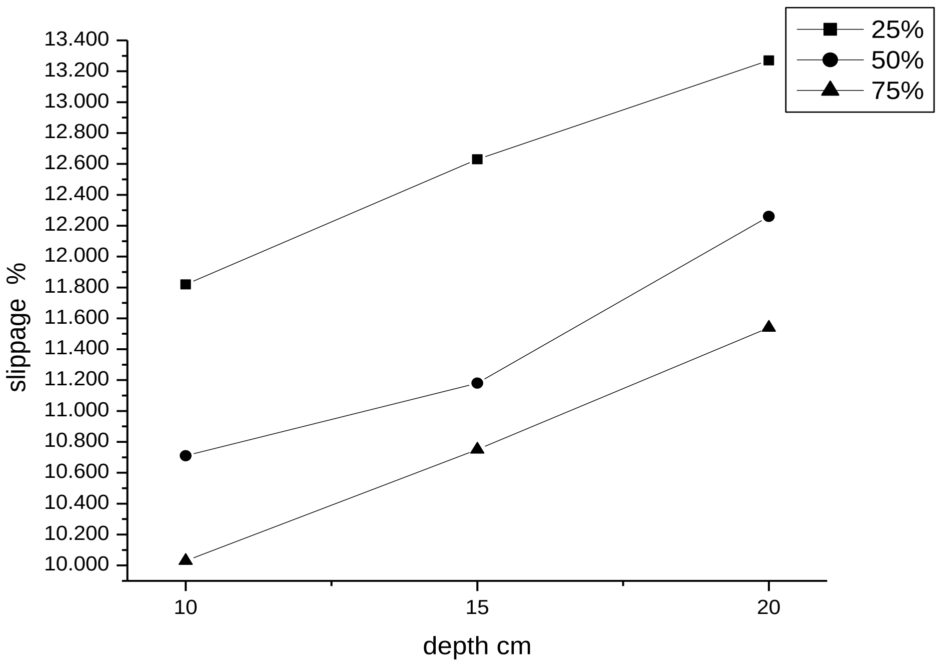

Figure (1) Effect of water ballast levels and depths on the slippage.

Table (2) Effect of different water ballast levels and depths on slippage (S), rolling resistance force (Fr), draft force (D) and fuel consumption (Q).

Water ballast levels	Depth cm	S %	Fr kN	Fd kN	Q L/h
25%	10	11.82	1.83	4.33	3.97
	15	12.63	1.83	6.00	4.85
	20	13.27	2.00	8.33	5.74
50%	10	10.71	2.33	5.33	4.52
	15	11.18	2.50	7.33	5.55
	20	12.26	2.66	10.33	6.87
75%	10	10.03	2.67	6.00	5.10
	15	10.75	2.83	7.83	6.50
	20	11.54	3.50	11.50	7.80

Effect of water ballast levels and depths on rolling resistance force (Fr):

Table (2) and figure (2) showed the average rolling resistance affected by three water ballast levels and three depths. . The effect of water ballast levels on rolling resistance was highly significantly different at level 1%. The effect of the depths on rolling resistance showed no significant differences at level 1%.

At 25% water ballast level with depths of 10 cm and 15 cm recorded lowest values of rolling resistance. Water ballast level 75% at depth 20 cm recorded highest value of rolling resistance. Increasing the water ballast levels from 25% to 75% at a depth of 20 cm increased rolling resistance by 43%. Increasing the depth of tillage from 10 cm to 20 cm with the water ballast level 50% increased the rolling resistance by 13%.

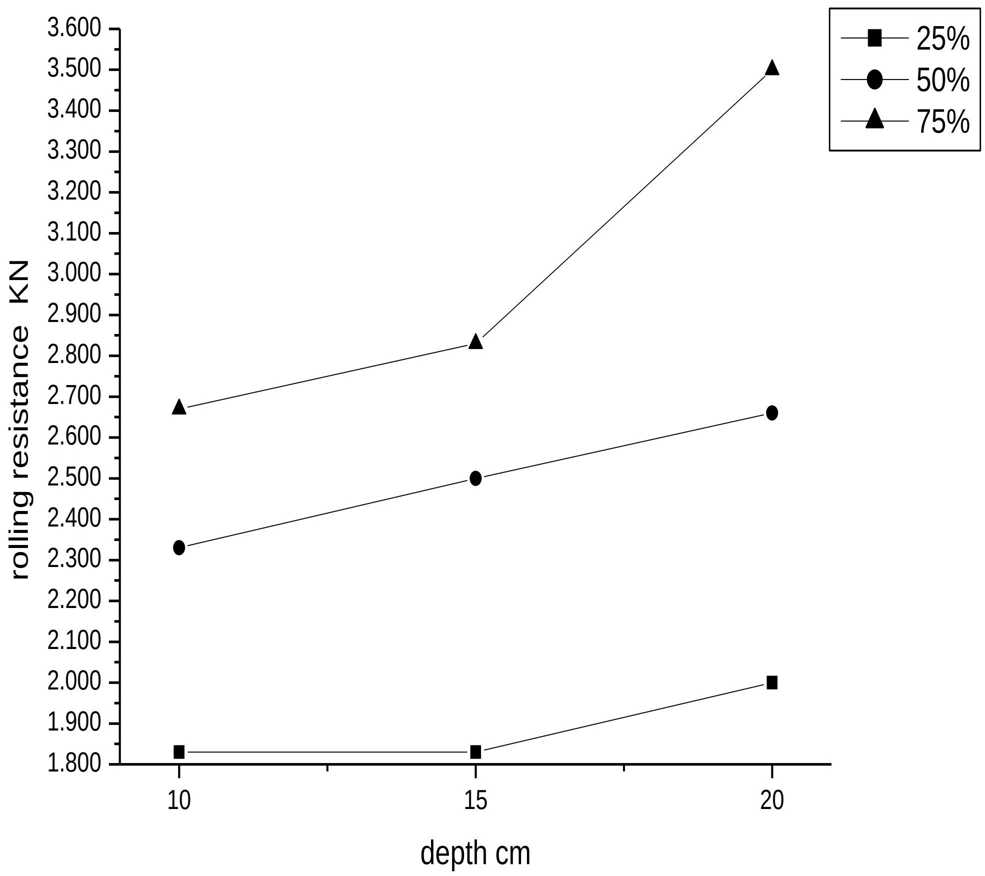

Figure (2) Effect of water ballast levels and depths on rolling resistance.

Effect of water ballast levels and depths on draft force (Fd):

Table (1) and figure (3) showed the average draft was affected by three Water ballast levels and three depths. The draft was affected by different water ballast showed highly significantly different at level 1%. The draft was affected by different depth showed highly significantly different at level 1%. The lowest value of draft 4.33 kN was recorded at 25% water ballast level and depth 10 cm. The highest value of draft 11.50 kN was recorded with 75% water ballast level and depth 20 cm. At 25% water ballast level, draft was increased 48%.when the depth of tillage increased from 10 cm to 20 cm. The water ballast levels was Increased from 25% to 75% at the depth of 10 cm the draft was increased by 22%. Increasing the water ballast levels from 25% to 75% at the depth of tillage 15 cm the draft was increased by 25%. Increasing the water ballast levels from 25% to 75% at a depth of tillage 20 cm the draft was increased by 26.4%. The draft was increased with the depth of tillage increased agreement with Aballaha, (2008).

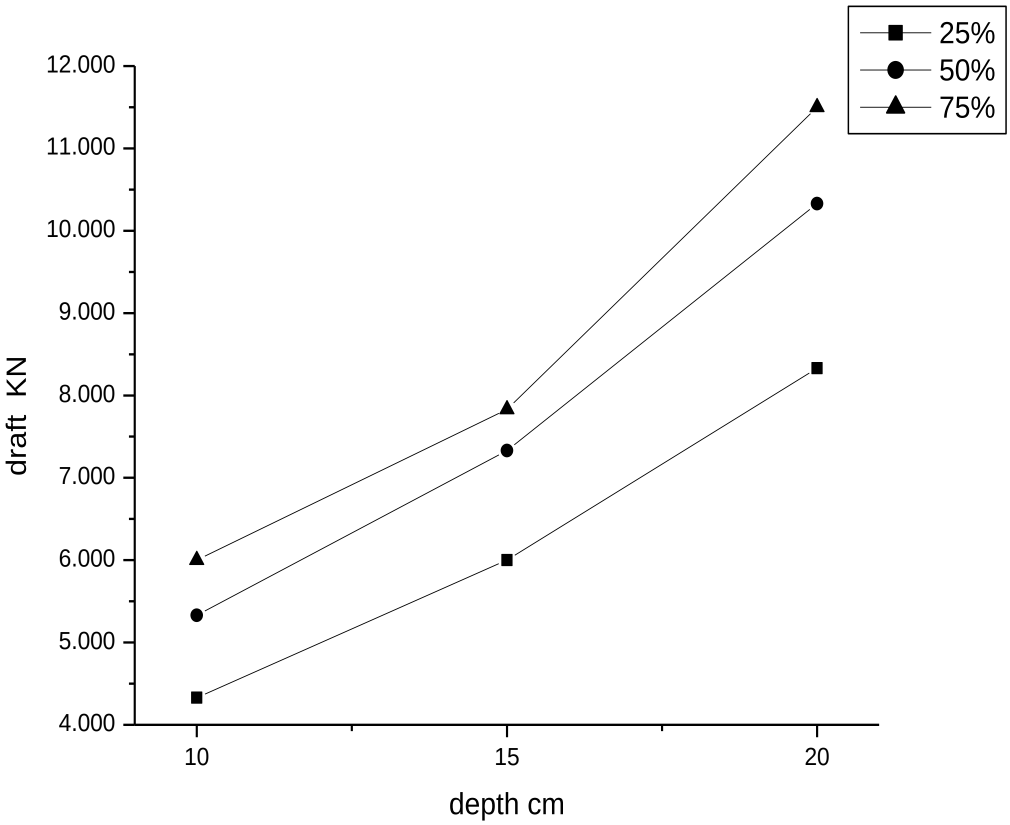

Figure (3) Effect of water ballast levels and depths on draft force.

Effect of water ballast levels and depths on fuel consumption (Q):

Table (2) and figure (3) showed the average of the fuel consumption was affected by three Water ballast levels and three depths. The fuel consumption was effected by different water ballast levels showed highly significant deferent at level 1%. The fuel consumption was effected by different depths showed highly differences significant at level 1%.

The lowest value of the fuel consumption 3.97 L/hr was recorded at 25% water ballast level and depth 10 cm. The highest value of the fuel consumption 7.80 L/hr was recorded with 75% water ballast level and depth 20 cm. The water ballast level 50% was recorded among values between water ballast levels 25% and 75%. Increasing the water ballast levels from 25% to 75% at the depth of tillage 10 cm, the fuel consumption was increased by 22%. Increasing the water ballast levels from 25% to 75% at the depth of tillage 15 cm, the fuel consumption was increased by 25%. Increasing the water ballast levels from 25% to 75% at the depth of tillage 20 cm the fuel consumption was increased by 26%. The fuel consumption was increased with the depth of tillage increased agreement with Aballaha, (2008). And Tayel et al, (2015). The fuel consumption was increased where the water ballast levels increased agreement with Mohamed (2015).

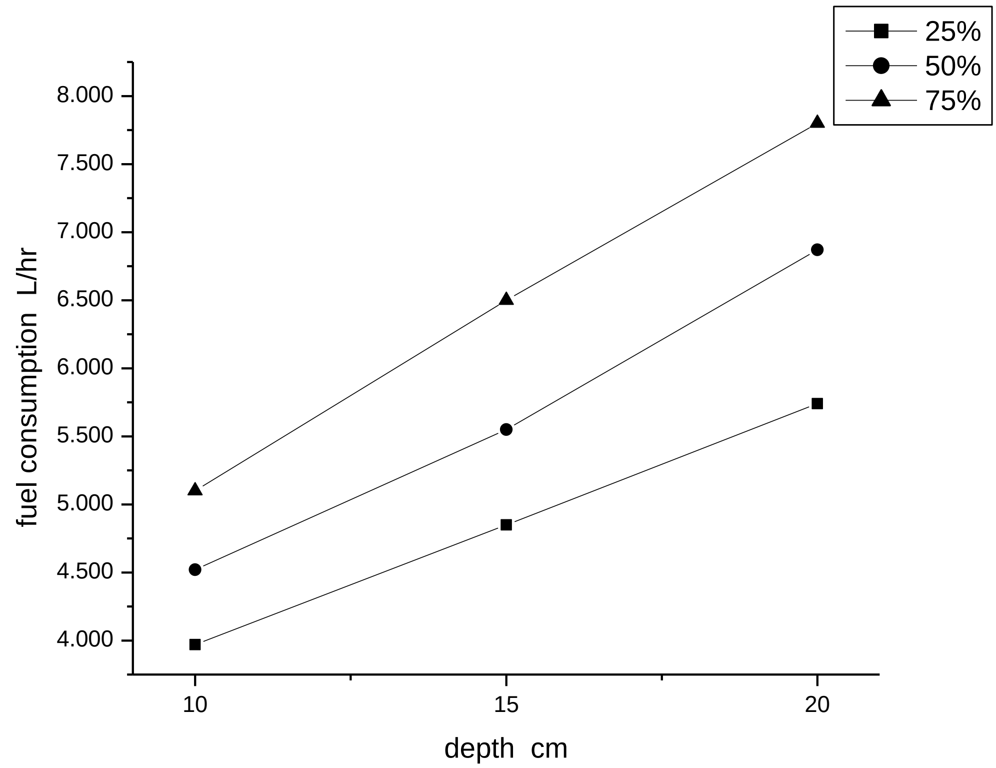

Figure (4) Effect of water ballast levels and depths on fuel consumption.

4-Conclusions

The following conclusions can be drawn:

- Slippage was decreased with increasing the water ballast levels, and it was increased with increasing the depths.
- Increasing the water ballast levels from 25% to 75% at 15 cm depth, the slippage was decreased by 17%. Rolling resistance force was increased with increasing the water ballast levels and depths.
- Draft force was increased with increasing the depths and water ballast levels. Fuel consumption was increased by increasing the water ballast levels and depths of tillage.
- Fuel consumption was increased by increasing the water ballast levels and depth of tillage.
- At 75% water ballast level with depth 20 cm was recorded the highest values of fuel consumption

5-Recommendation

According to the results of this study the following recommendation can be state:

1- It's better to use the 75% water ballast level in the rear tires for better tractor performance.
2- Repeat this research with different pressure in the rear tires

6-References

1- Abbouda, A. H (2001). The Effect of some Operating Parameters on Field Performance of A 2WD Tractor. Scientific Journal of King Faisal University. Vo. 2.No. 1.

2- Abdallah, B .A (2008). Effect of Plowing Depth and Speed of Three Tillage Implements on Tractor Performance, unpublished M.Sc. Thesis, University of Khartoum, Sudan.

3- Bauer, F., Sedlák, P., Čupera, J., Polcar, A., Fajman, M., Šmerda, T. And Katrenčík, J.)2013). Tractors and Their Use [In Czech: Traktory A JejichVyužití]. Praha: Profi Press S.R.O.

4- Brixius, W. W. (1987). Traction prediction equations for bias-ply tires. ASAE Paper No. 871622. St. Joseph, Mich.:ASAE.

5- Elani, R. N. A. (1994). Utilization Of Tractor And Agricultural Machinery –Lectures Dept.Of Agricultural Mechanic - Faculty Of Agricultural. University Of Bagdad.

6- Maali, A. E (2010) Effect Of Soil Moisture Content And Tillage Implement Type On Agriculture Tractor Traction Performance. Thesis, Faculty of Agriculture University of Khartoum.

7- Masiero (2010). F. C. Determination of income in the drawbar agricultural tractors with front wheel assists (4X2 TDA). 79 f. Dissertation (Master in Agronomy, Energy in Agriculture) - Agronomical Sciences Faculty, University of São Paulo State, Botucatu.

8- Mohammed, B. (2015). Effect of Rear Wheels Inflation Pressure and Additional Weights on Tractor Performance Using Moldboard Plow on Heavy Clay Soil. Sinnar University Journal. Vol. 4, No.2: 55-78.

9- Moitzi. G, H. Wagentristl, K. Refenner, H. Weingartmann, G. Piringer, J. Boxberger, A. Gronauer. (2014). Effects of working depth and wheel slip on fuel consumption of selected tillage implements. AgricEngInt: CIGR Journal. Vol. 16, No.1: 182-190.

10- Monteiro, L. A.; Lanças, K. P. ; Guerra S. P. S (2011). Performance of an agricultural tractor equipped with radial and diagonal tire with three levels of liquid ballast. Engenharia Agrícola, Jaboticabal, v. 31, n. 3, p. 551-560.

11- Naderloo. L, R. Alimadani, A. Akram, P. Javadikia and H. Zeinali Khanghah (2009). Tillage depth and forward speed effects on draft of three primary tillage implements in clay loam soil. Journal of Food, Agriculture & Environment Vol.7 ,: 382-385.

12- Qaisrani, A.R; Chen Bingcong and M.N Farooq. (1992). Tractor ballasting and its effects on wheels slip and fuel consumption. Pro. Of Inter. Conf. on Agr. Eng. (92-ICAE) Beijing 12-14 Oct. Vol1.

13- Tayel M.Y.; Shaaban S. M. and Mansour H. A. (2015). Effect of Plowing Conditions on the Tractor Wheel Slippage and Fuel Consumption in Sandy Soil International Journal of Chem Tech Research, Vol.8, No.12 .pp 151-159.