FIELD COMPARISON OF THE PERFORMANCE OF SLATTED AND GENERAL PURPOSE MOLDBOARD

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ABSTRACT

Factorial experiment within randomized complete block design using three replication for field comparison performance slatted and general-purpose moldboard plow. Using least significant design (LSD) 1 % and 5 % was used to compare the mean of treatments. Three factors were used, the first one was depths of tillage 15 and 25 cm, the second was speed of tractor 4.146 and 7.224 km/hr, and the third factor was types of moldboard, slatted and general-purpose moldboard. Slatted moldboard recorded the least slippage of 9.697 %, the fuel consumption of 23.580 L/ha and higher effective field capacity of 0.4239 ha/hr, and field efficiency of 72.543 %. Depth of tillage 15 cm got the least slippage of 6.364 %, fuel consumption of 20.182 L/ha and higher and higher effective field capacity of 0.4402 ha/hr, and field efficiency of 74.187 %. Speed 7.224 km/hr got least fuel consumption 22.939 L/ha and a higher adequate field capacity of 0.5246 ha/hr. Interaction between treatments had a significant effect.

Keywords: Factorial experiment, Tractor, Tillage, Fuel, Design and Manufacture.
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مقارنة حقلية لأداء المطرحة اللوحية ومطرحة الأغراض العامة

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المستخلص

نُفذت تجربة عاملية بنظام القطاعات العشوائية الكاملة وبثلاثة مكررات بهدف مقارنة أداء المطرحة اللوحية والمطرحة للأغراض العامة حقلياً، وحُللت النتائج إحصائياً واختبرت الفروق بين المعاملات بطريقة أقل فرق معنوي 1% و5 %. ثلاثة عوامل استخدمت الأول عمق الحراثة بمستويين 15 و25 سم والثاني سرعة الجرار 4.146 و 7.224 كم/ساعة والعامل الثالث نوع المطرحة بنوعين المطرحة اللوحية والمطرحة للأغراض العامة. تفوقت المطرحة اللوحية بتسجيلها أقل نسبة مئوية للانزلاق 9.697% وأقل نسبة استهلاك وقود 23.580 لتر/هكتار وأعلى سعة حقلية عملية 0.4239 هكتار/ساعة وكفاءة حقلية 72.543%. عمق الحراثة 15 سم حقق أقل نسبة مئوية للانزلاق 6.364% وأقل كمية استهلاك وقود 20.182 لتر/هكتار وأعلى سعة حقلية 0.4402 هكتار/ساعة وكفاءة حقلية 74.187%. سرعة الجرار 7.224 كم/ساعة حققت أقل كمية استهلاك وقود 22.939 لتر/هكتار وأعلى سعة حقلية 0.5246 هكتار/ساعة. التداخلات بين المعاملات كان لها تأثير معنوي.

الكلمات المفتاحية: تجربة عاملية، جرار، حراثة، وقود، تصميم وتصنيع.
*** جزء من أطروحة الدكتوراه للباحث الأول.**

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INTRODUCTION

In the technological chain of the field crop production, soil tillage is an enormous energy-consuming activity, leading to high fuel price, so reducing the fuel consumption should be considered seriously. Many researchers have conducted researches related to conventional tillage to achieve the best performance and increase crop productivity (4, 7, 10, 16, 20). Increasing tractor speed, actual width cut, depth of tillage and soil moisture content will result in increasing power requirement in tillage equipment use and that lead to increasing amount of fuel consumption (15, 19, 21). Slipping occur between surface such as soil and tire tractor, it is reduction in distance travel and /or speed, and the permissible percentage of slippage is less than 15 % for tractors (24). Effective field capacity, field efficiency Slippage are affected by some factors, such as soil condition, tractor weight, speed of tractor, depth of plowing, plow width tire type, and tire air pressure (14 and 18). Speed tractors must be selected carefully because every operation and machine agriculture has an applicable speed limit, yet we still need to experiment to know which suitable speed gives the best indicator performance (9). Increase speed of tractor lead to increasing slippage and effective field capacity and reducing fuel consumption (2). The aim of this study is comparison performance between slatted moldboard and general-purpose moldboard under variable depths of tillage and speeds of a tractor in the field experiment.

MATERIALS AND METHODS

Field experiment: A field experiment was conducted in the Jaderaya zone in the collage of Agricultural Engineering Science at the University of Baghdad in 2022. The field was 31.7 m above sea level, the weather temperature was measured at 18 C^{o}, and the humidity was 46 %, Soil texture was sandy loam (572 sand, 340 loam, and 88 clay g.kg-1), and soil moisture was 16 - 18 % when soil was tilled.

Experiment design: Factorial experiment under randomized complete block design with three replication using least significant design (LSD) 1 % and 5 % was used to compare the mean of treatments. A statistical analysis system (SAS) was used (23). Three factors were used in this experiment, the first one was depths of tillage 15 and 25 cm, the second factor was the speed of tractor 4.146, 7.224 km/hr, and the third factor was the types of moldboard plow one of them designed and manufactured by the researcher which slatted moldboard plow and second was general-purpose moldboard. The experiment included 8 treatments with three replication for each treatment (2×2×2×3= 24 Treatments).

Tractor and plow: New Holland tractor TD 80 with 75 hp was used in this experiment, with four cylinders and water-cooling system. Standard tires were used as specified by the manufacturer with no damaged, and all the tire pressures were adjusted. Operation tillage conducted with 2000 rpm engine tractor by put and control on lever fuel hand in tractor for all treatments in these experiment. Moldboard plow contain three general purpose moldboard, width 1.05 m, maximum depth work 27 cm and weight 316 kg. According to the experiment design, the slatted moldboard consist of five slats tied in the plow instead of the original mold board, a general-purpose moldboard during the field experiment (fig.1-a and b).

a

b

Fig.1 plow. a- Slatted moldboard, b- General purpose moldboard

Performance parameter:

Slippage percentage: It is the asymmetry between the length of the linear and circumferential distance for a fixed number of revolutions of the driving wheels of the tractor, and often the linear distance is relatively less than the circumferential distance (3). It was calculated by using the equation:

$$S = \left[\frac{V_t - V_p}{V_t}\right] \times 100 \quad (1)$$

$$V_t = \left(\frac{S_t}{T_t}\right) \times 3.6 \quad (2)$$

$$V_P = \left(\frac{S_p}{T_p}\right) \times 3.6 \quad (3)$$

When *S* is slippage percentage %, *Vt* is theoretical velocity km/hr, *Vp* is the actual velocity km/hr, *St* and *Sp* are distance (20 m), *Tt* is theoretical time (sec) and *Tp* is practical time (sec).

Effective field capacity: It defines the actual performance of the plow in the field. During operation tillage there are time losses such as turning, adjustment and changing gear. The effective field capacity was calculated by using the equation (6):

$$EFC = 0.1 \times V_a \times W_p \times ft \quad (4)$$

When *EFC* was Effective Field Capacity in ha /hr, *Va* was actual speed tractor in km/hr, *Wp* was working actual width plow in m, *ft* coefficient estimate time for primary tillage in Iraq agriculture depends on it almost between (0.75 – 0.85), and we used 0.80 in these experiments (17) and 0.1 was factor conversion.

Field efficiency: It is the ratio between effective field capacity and theoretical field capacity, and its value is always less than one (11). It was calculated by using the equation:

$$FE = \left(\frac{EFC}{TFC}\right) \times 100 \quad (5)$$

$$TFC = 0.1 \times V_t \times W_t \quad (6)$$

When *FE* is field efficiency %, *TFC* is theoretical field capacity ha/hr, *Vt* is theoretical speed tractor

Fuel consumption: The amount of fuel consumption by the tractor during the tillage operation was measured using the method of refilling the fuel tank tractor before and after every operation. This way involved filling of the tractor fuel tank to the brim before and after each operation test performed, using a 1000 ml graduated cylinder, from where the quantity of fuel used is measured per time of the operation (1, 8, 22). Fuel consumption calculated by follow the equation (13):

$$Q_F = Q_d \times 10000 — W_p \times D \times 1000 \quad (7)$$

When *QF* was quantity fuel consumption measure unit L/ha, *Qd* was quantity fuel consumption during one treatment measure unit milliliter (ml), *D* is length of treatment (20 m) and 10000 and 1000 were factors conversion.

RESULTS AND DISCUSSION

Slippage percentage: Results showed an increasing slippage percentage from 6.364 to 13.946 % when increasing the depth of tillage from 15 to 25 cm, because of increased load on the plow resulted from increase in mass of the soil cut by the plow share, and that result agree with (5). Increase speed of tractor from 4.146 to 7.224 km/hr lead to increasing slippage from 7.609 to 12.701 %, and that because of the increase in traction resistance and also reduces the grip of the rear wheels driving the tractor with field soil, and that result agree with (6). Result show slatted moldboard plow recorded least value 9.697%, while general purpose moldboard was 10.613%, that because of the smaller contact area in case of slatted moldboard and less friction between soil and slatted moldboard comparing with general purpose moldboard plow. Interaction depths of tillage and speed tractor were significant. Interaction depth of tillage 15 cm and speed of 4.146 km /hr recorded least value of 4.349 %, while the depth 25 cm with speed of 7.224 km /hr recorded higher value of 17.023 % (fig.2). Interaction depths of tillage and moldboard plow was significant, interaction depth of tillage 15 cm and slatted moldboard plow recorded least value 5.812 %, while depth 25 cm with general purpose moldboard recorded higher value 14.310 %. Interaction speed tractor with moldboard types was no significant. Fig. 2 Shows interaction among depths of tillage, speed of tractor and moldboard types in slippage. Interaction depth of 15 cm, speed 4.146 km/hr, and slatted moldboard recorded the least slippage at 3.987 %, while the tillage depth of 25 cm and speed of 7.224 km/hr recorded a higher value 17.613 % (fig.3).

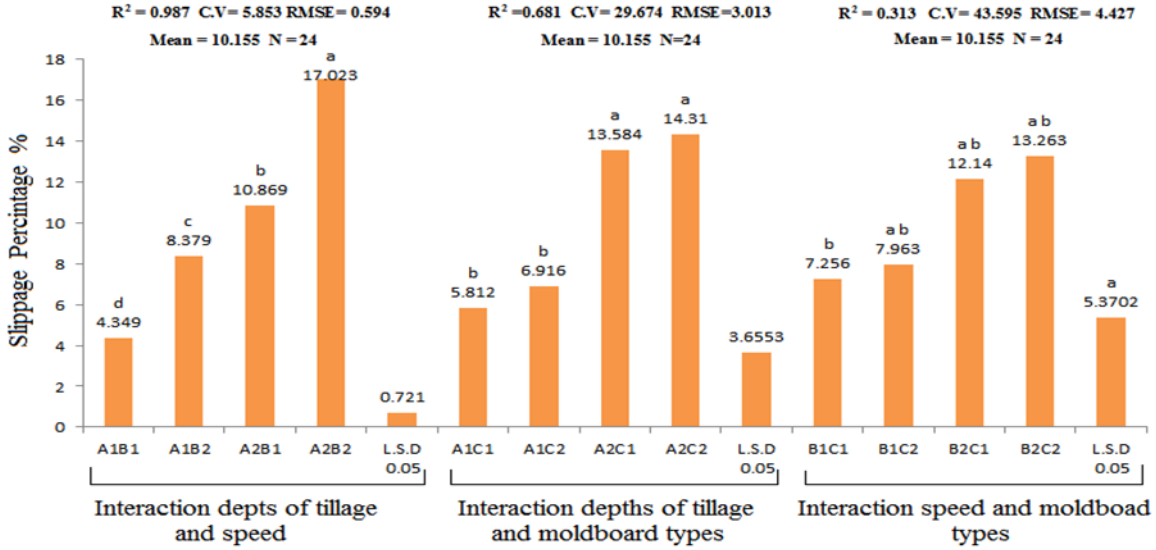

Fig.2 Binary interactions depths of tillage, speed and moldboard types on slippage

A1=15 cm A2=25 cm B1= 4.146 B2= 7.224 km/hr C1= Slatted moldboard C2= General purpose moldboard (The same latter meaning No significant).

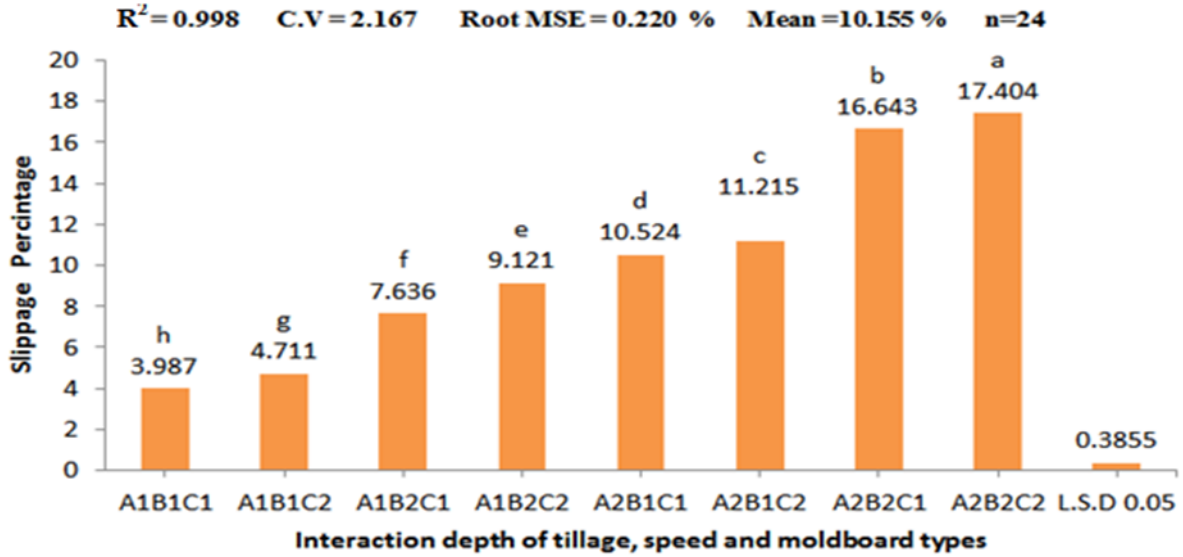

Fig. 3. Triple interaction of depth of tillage, speed of tractor and moldboard types on slippage

Effective field capacity

Results showed decreasing effecting field capacity from 0.4293 to 0.4193 ha/hr when increasing the depth of tillage from 15 to 25 cm, because increasing the depth of tillage leads to increase in load and decrease in the speed of the tractor, which is one of the factors calculating the productivity, and that result agrees with (5). Increase speed of tractor from 4.146 to 7.224 km/hr lead to increasing effective field capacity from 0.3186 to 0.5246 ha/hr, and that because of the speed is one of the factors calculating the effective field capacity. Result show slatted moldboard plow recorded slight increase value 0.4239 ha/hr, while general purpose moldboard was 0.4193 ha/hr, and that because of the difference in the time of the distance traveled during each plowing treatment and thus leads to a difference in the speed of each plow. Interaction depths of tillage and speed tractor was significant, interaction depth of tillage 25 cm and speed 4.146 km /hr recorded least value 0.3074 ha/hr, while depth 15 cm with speed 7.224 km /hr recorded higher value 0.5106 ha/hr (fig.4). Interaction depths of tillage and moldboard plow were not significant. Interaction speed tractor with moldboard types was Significant, interaction speed of tractor 4.146 km/hr with general purpose moldboard recorded least value 0.3174 ha/hr, while speed 7.224 km/hr with slatted moldboard recorded 0.5280 ha/hr. Fig. 3 Shows interaction among depths of tillage, speed of tractor and moldboard types in effective field capacity, Interaction depth of

tillage of 15 cm, speed of 4.146 km/hr and general purpose moldboard recorded the least value of 0.3286 ha/hr, while the depth of tillage of 15 cm, speed of 7.224 km/hr, and slatted moldboard recorded a higher value of 0.5551 ha/hr (fig 5).

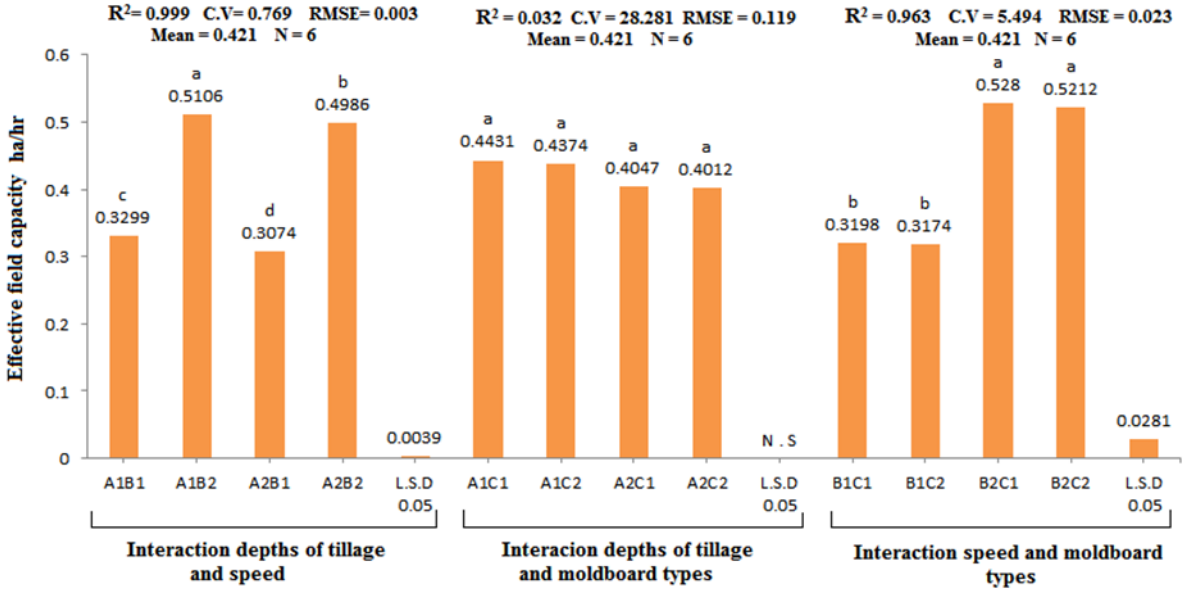

Fig.4 Binary interactions depths of tillage, speed and moldboard types on Effective field capacity

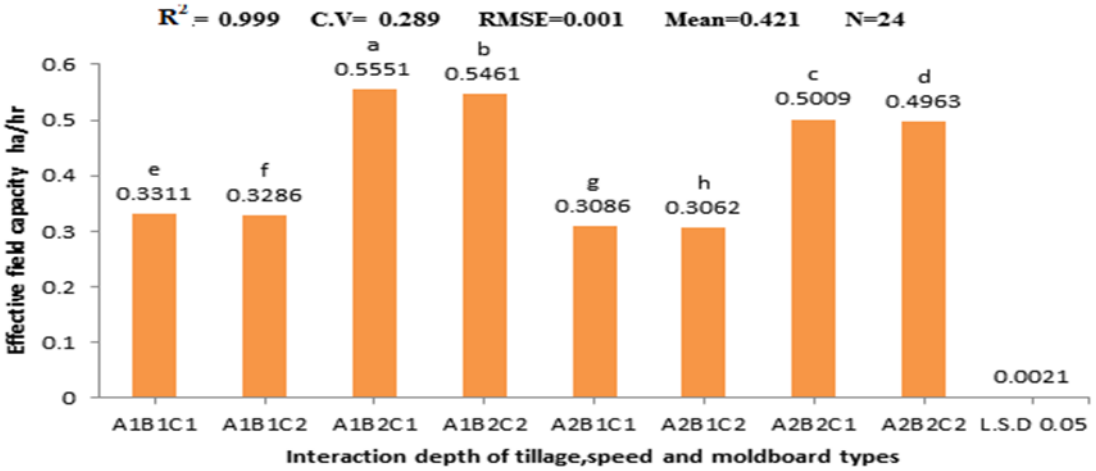

Fig.5 Triple interactions depths of tillage, speed and moldboard types on Effective field capacity

Field efficiency

Results showed decreasing field efficiency from 74.187 to 68.175% when increasing the depth of tillage from 15 to 25 cm, and that because of increasing the depth of tillage was accompanied by a decrease in the speed of the tractor, which is one of the most important factors involved in calculating the effective field capacity, which led to its reduction and consequently to a decreased efficiency. Increase speed of tractor from 4.146 to 7.224 km/hr lead to decreasing field efficiency from 73.197 to 69.165 %, and that because of reduce coefficient of utilization of time. Results show slatted moldboard plow recorded slight increase value of 71.543 %, while general-purpose moldboard was 70.819 %, because of the slippage and coefficient of utilization of time. Interaction depths of tillage and speed of tractor was significant, interaction depth of tillage 15 cm and speed 4.146 km /hr recorded higher value 75.782 %, while depth 25 cm with speed 7.224 km /hr recorded higher value 65.737% (fig. 6). Interaction depths of tillage and moldboard plow were significant, interaction depths of tillage 15 cm with slatted moldboard recorded higher value of 74.625%, while depth 25 cm with general-purpose moldboard recorded the least value of 67.888 %. Interaction speed of tractor with moldboard types was significant, interaction speed of tractor 4.146 km/hr with

slatted moldboard recorded higher value of 73.467 %, while speed 7.224 km/hr with general purpose moldboard recorded least value 68.721%. Fig. 4 Show interaction among depths of tillage, speed of tractor and moldboard types in field efficiency, Interaction depth of tillage 15 cm, speed 4.146 km/hr and slatted moldboard recorded higher value 76.068 %, while the depth of 25 cm, speed 7.224 km/hr and general-purpose moldboard recorded the least value of 65.438% (fig.7).

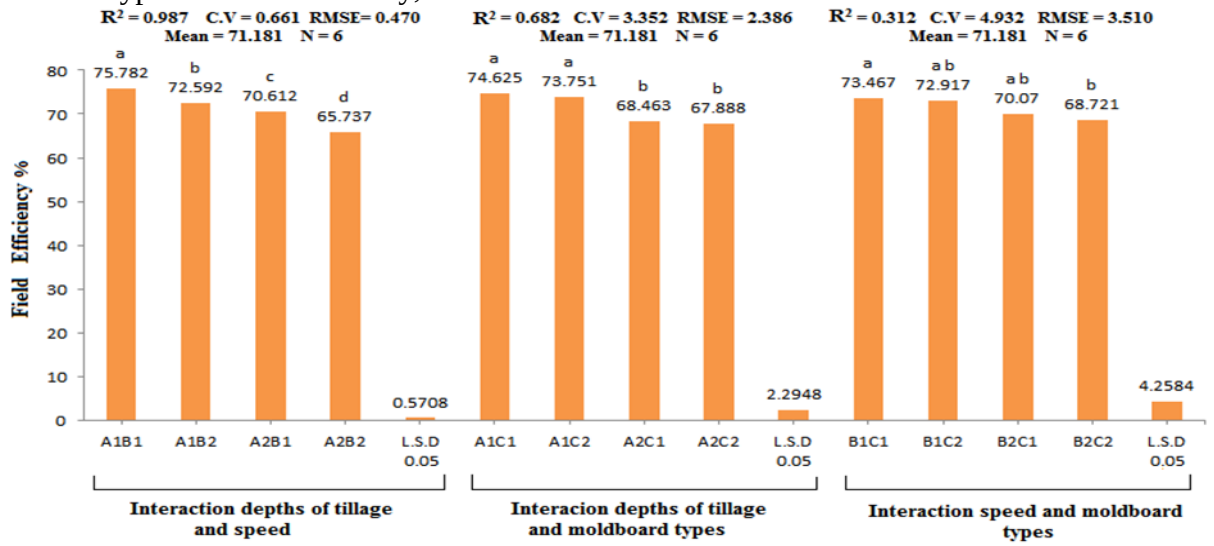

Fig.6 Binary Interactions depths of tillage, speed and moldboard types on field efficiency

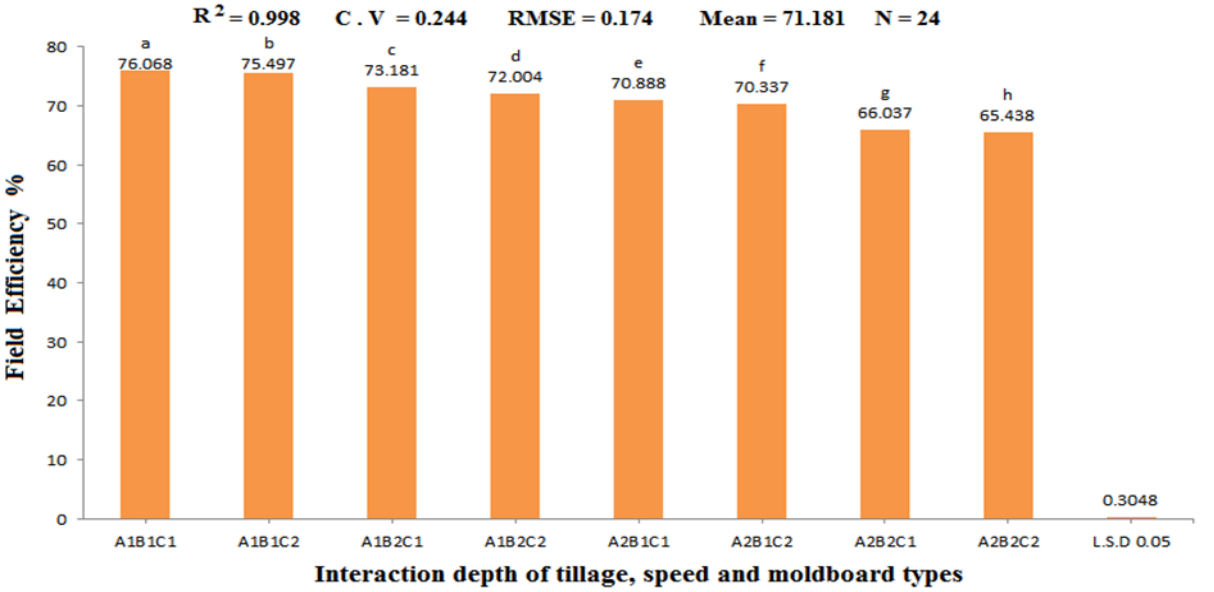

Fig.7 Triple interactions depths of tillage, speed and moldboard types on field efficiency

Fuel consumption

Results showed increasing fuel consumption from 20.182 to 27.510 L/ha when increasing the depth of tillage from 15 to 25 cm, because of an increase in load on the plow as a result of the increase in mass of soil cut by the plow share, and results agree with (5). Increasing tractors speed from 4.146 to 7.224 km/hr leads to decreasing fuel consumption from 24.753 to 22.939 L/ha, because of the better utilization of the engine capacity to complete the plowing process, that result agrees with (12).Results show that slatted moldboard plow recorded least fuel consumption 23.580 L/ha, while general-purpose moldboard was 24.312 L/ha, because of the smaller contact area in the slatted moldboard and less friction between soil and slats and better utilization time compared with a general-purpose moldboard plow. Interaction depths of tillage and speed tractor was significant, interaction depth of tillage 15 cm and speed 7.224 km /hr recorded least value 19.470 L/ha, while depth 25 cm with speed 4.146 km /hr recorded higher value 28.613 L/ha (fig. 8). Interaction depths of tillage and moldboard plow were significant,

interaction depth of tillage 15 cm and slatted moldboard plow recorded the least value of 19.765 L/ha, while depth of 25 cm with general-purpose moldboard recorded a higher value of 28.026 L/ha. The interaction speed of tractors with moldboard types was not significant. Fig. 9 Shows interaction among depths of tillage, speed of tractor, and moldboard types in fuel consumption, Interaction depth of 15 cm, speed 7.224 km/hr, and slatted moldboard recorded least value of 19.150 L/ha, while the tillage depth 25 cm and speed 4.146 km/hr and general-purpose moldboard recorded a higher 29.326 L/hr.

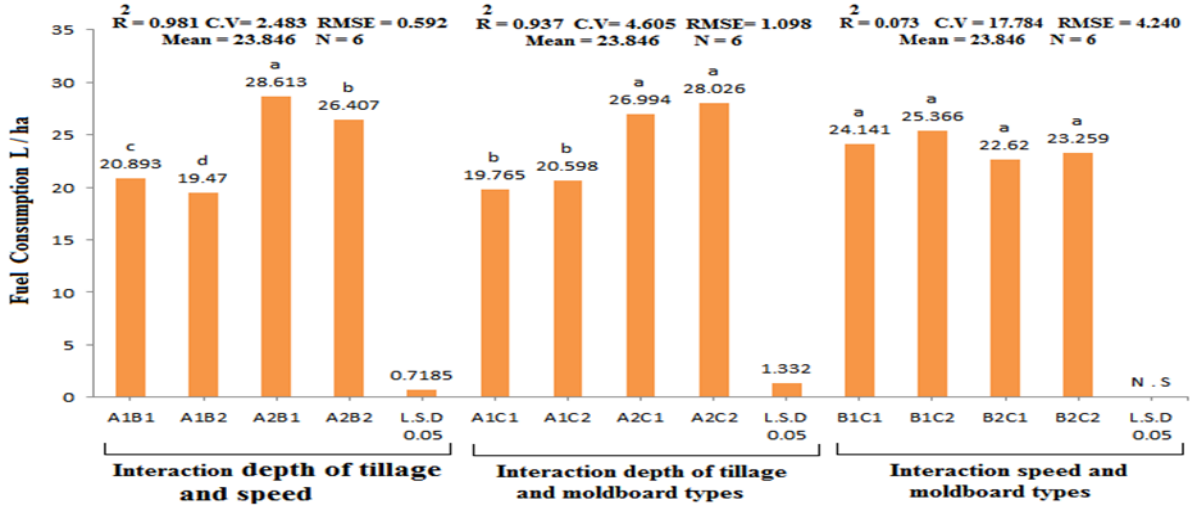

Fig.8 Binary interactions depths of tillage, speed and moldboard types on fuel consumption

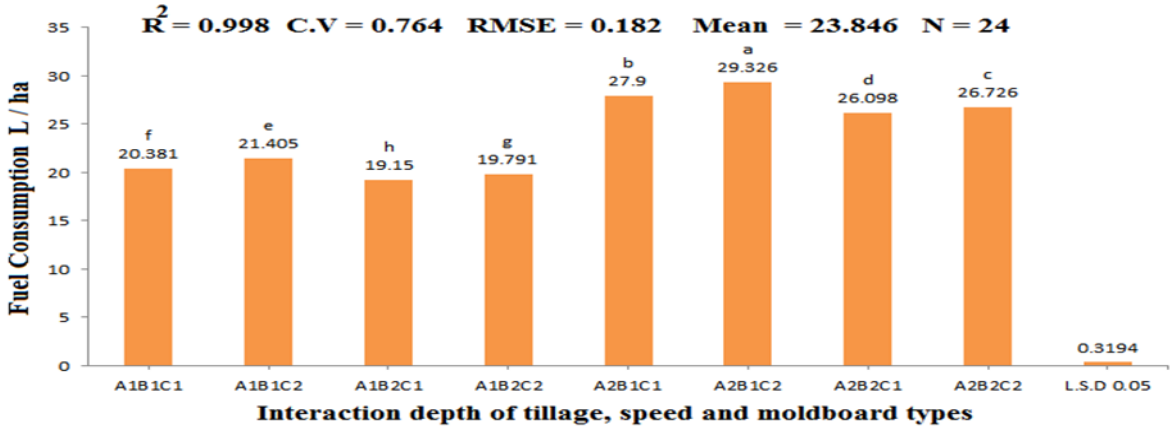

Fig.9 Triple interactions depths of tillage, speed and moldboard types on fuel consumption

CONCLUSION

Finally, in light of these findings, it can be concluded that the slatted moldboard achieved the best (minimum) value of slippage percentage and fuel consumption in all depths of tillage and speed of the tractor. Slatted moldboard gets higher adequate field capacity and field efficiency. Depth of tillage 15 cm achieved the least slippage value and fuel consumption and higher affective field capacity and field efficiency. Speed of tractor 7.224 km/hr was achieved higher affective field capacity and least fuel consumption.

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