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FIELD PERFORMANCE OF A MODIFIED CHISEL PLOW

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ABSTRACT

Conventional and modified with wide winged tools chisel plow was operated in clayey. Total field time showed no significant difference between two designs in each location at 0.05 level. The conventional plow showed higher speed than modified plow in the first location and second location. Theoretical field capacity recorded by conventional plow was higher than that recorded by modified plow by 0.11ha/h in the first location and by 0.18ha/h in the second location:, respectively. The effective field capacity of conventional plow was higher than that for modified plow by 0.064 ha / h in the first location and by 0.137 ha / h in second location. Field efficiency of conventional plow was lower than that for the modified plow. Fuel consumption rate recorded by conventional plow was higher than the rate recorded by modified plow by 0.10 L / ha in first location. The results showed that the crop yield recorded by the conventional plow was lower than that recorded by modified plow by 47.7 kg / ha in the first location and by 50.1 kg / ha in the second location.

Keywords: Modified chisel plow, Wide triangular winged tool.

Contribution/ Originality

The present study contributes in the existing literature by providing data and information concern with field capacities, field efficiency, fuel consumption and sorghum crop yield using a locally modified rear conventional chisel tools with relatively wide triangular winged shares in the crusty clayey sand soil of North Kordofan State in Sudan, where the tractor drawn plows are not used and the sorghum yield is very low.

1. INTRODUCTION

Tillage may be defined as the mechanical manipulation of soil for any purposes. In agriculture the main objective of tillage is to provide optimum condition for plant growth [1]. Mouazen and

Ramon [3] and Baloch, et al. [2] mentioned that the variation in fuel consumption and energy requirements for primary tillage could be related to variables such as soil type and its conditions, depth and width of cut, tool shape and geometry, manner of tool movement, previous treatments and crops, ground cover, tillage system and operation speed. It was found that the draft force and tillage energy required during tillage using chisel plow is linear function with operation speed, directly proportional to plowing depth and width, tool characteristics, and soil properties [4] and Chandon and Kushwaha [5]. Kirisci [6] found that the relationship between force and depth is linear for chisel plow. Bowers [7] measured the tillage draft and fuel consumption for the major implements used in crop production systems in 12 soils series at North Carolina. It was found that the tillage draft was about 8.24 kN. In other study Iqbal, et al. [8] found that the draft consumed by chisel plow increased linearly with the increase in depth of cultivation. El-Sayed and Ismail [9] found that the energy required for traditional, minimum and improved tillage treatment was 48.64, 25.13 and 67.38 kw.h/fed., respectively. Metwaly [10] found that the energy requirement was increased at all tillage treatments as the tractor forward speed increased. El-Nakib and Fouad [11] found that soil bulk density decreased after tillage and the effects was much greater in the top layers than the lower ones. El Raie, et al. [12] studied the effect of different systems of tillage on the physical properties of the soil. They found that the bulk density was decreased for all tillage treatments and the total porosity and void ratio increased. Backingham [13] stated that typical range field efficiency of chisel plow was from 74 to 90%. El-Din [14] and Younis, et al. [15] found that the minimum energy required obtained with chisel plow was due to its high actual field capacity and low slip during the plowing.

Helmy, et al. [16] reported that field capacity was affected by tillage systems and working depth. However, El-Iraqi, et al. [17] stated that the modified chisel plow (4 rows Δ-shape) saved about 23 up to 59% in the power consumption and about 30 up to 58% in the energy requirements compared with other shapes of chisel plow (2 and 3 rows) at any given study parameters, in addition to obtain highest degree of plowing quality. Abdul Razzag [18] compared the performance four different implements in grassy land. The tested implements included rotavator, cultivator, and disk harrow and chisel plow. He concluded that the chisel plow was the most efficient and ideal to work clay soils covered with Sudan grass. The objective of the present work is to modify a chisel plow by replacing the rear raw with small moldboard type bottoms and testing its field performance.

2. MATERIALS AND METHODS

2.1. Tractors and Equipments

Massey Ferguson tractor (MF440) was used for the experiment measurements .The specifications of tractors are given in Table 1. The implement used in the present study was 1.5 m wide fully tractor mounted chisel plow with 7-Rigid shanks arranged in two rows, three shanks in the front row and four shanks in rear row.

2.2. Other Equipments

Four wide winged triangular shares, stop watch, metering tape, fuel container and 1 liter measuring cylinder were used.

Table-1. The Tractor Specifications

Model	Perkins, MF 440
Cylinders	4
Power	82 Horse power(Hp)
Engine speed rate (rpm)	2200
Max. engine torque (Nm)	288
Weight (Kg)	2665
Length (m)	3.98
Width (m)	2.06

2.2. Methods

2.2.1. Experiment

The experimental work was carried out in two locations of clayey sand soil 500 m apart each of 0.35 ha area. The experiment layout was shown in Fig. 1, the experiment was conducted using complete random design for two treatments namely, conventional chisel plow and modified chisel plow each treatment was replicated in four plots per location, each plot of 100 m x 4.0 m. Conventional chisel plow (Fig. 2 a) was first operated, then it was modified in the field by replacing the rear four tools with other wide winged triangular tools (Fig. 2 b).

2.2.2. Field Performance Parameters

The tractor operated in the plot, and then the time was recorded using stop watch. Total time was computed by adding productive time to turning time and other stops time.

The plowing speed was the calculated as follow

$$S = \frac{D}{t} \qquad (1)$$

Where,

S = plowing speed, km / h.

D = plot length, km.

t = time (h).

Theoretical field capacity in each plot was computed using the following equation

$$TFC = \frac{S \times W}{10} \qquad (2)$$

Where,

TFC = theoretical of field capacity (ha/h).

S = plowing speed, km / h.

W = width (m).

The effectiveness of field capacity was calculated:

$$EFC = \frac{A}{T} \quad (3)$$

Where,

EFC = effectiveness field capacity (ha / h).

A = plot area (ha).

T = time (h).

Field efficiency measurement

$$FE = \frac{EFC}{TFC} \times 100 \quad (4)$$

Fuel consumption measurement

Tractor started working the plot with full tank, after finishing the plot, the tank was refilled using measuring cylinder. The amount of fuel used to refill the fuel tank was recorded the fuel consumption rate was calculated as follows:

$$FCR = \frac{V_C}{A} \quad (5)$$

Where,

FCR = fuel consumption rate, L / ha.

V_C = reading of cylinder volume to refill the tank, L.

A = plot area, ha.

2.2.3 Seed Yield (crop yield)

Sorghum was used as tested crop, each plot in the two locations were grown with the crop. When the crop reached the maturity stage it was harvested and the seeds were weighted, the yield was then calculated as follow

$$Y = \frac{W}{A} \quad (6)$$

Where,

Y = seed yield (kg / ha).

W = seeds weight (kg).

A = harvest area (ha).

Fig-1. Experimental area layout for the first location as a model

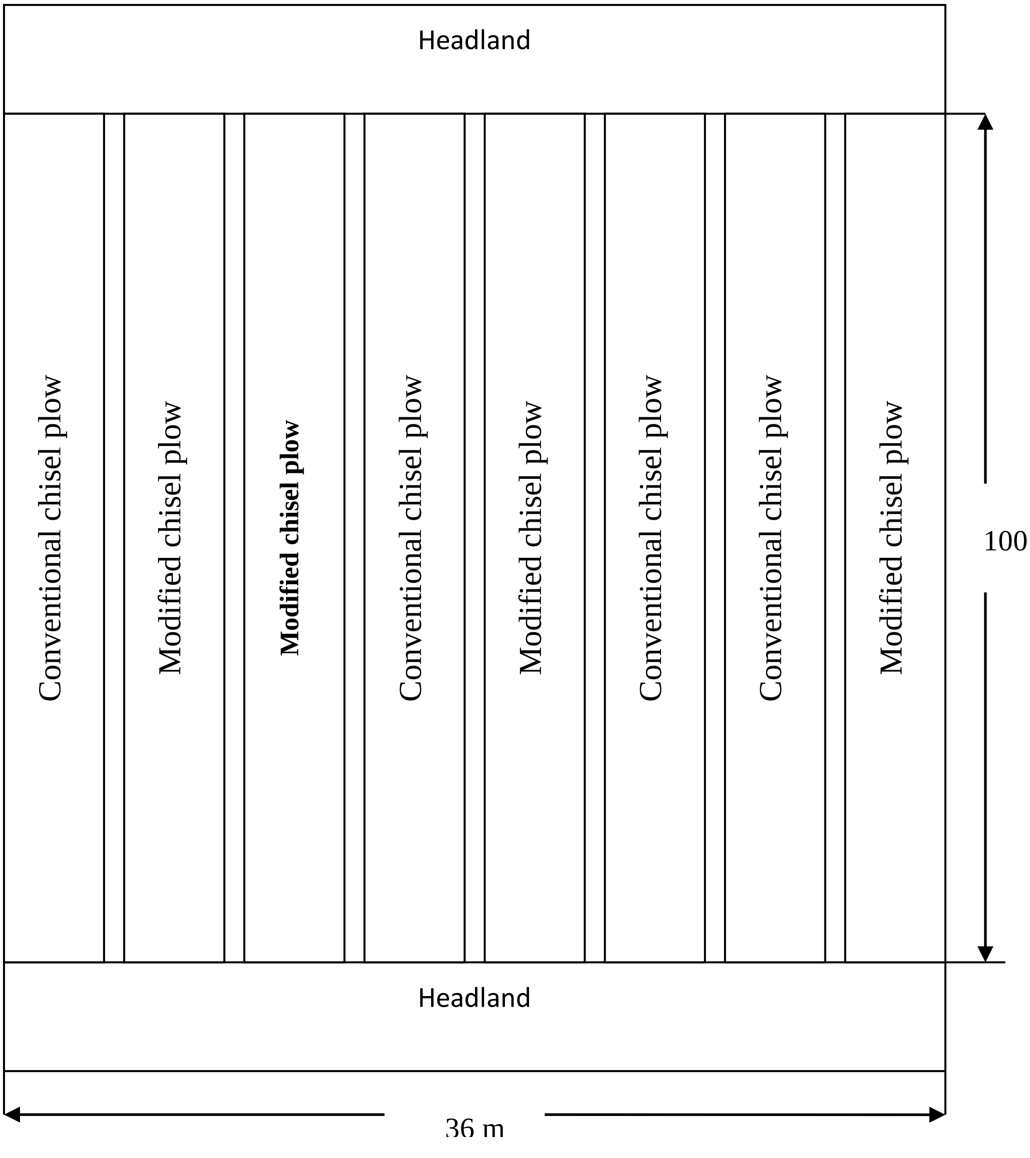

Fig-2. Cutting tools implement

(a) Conventional chisel tool (b) Wide winged triangular tool

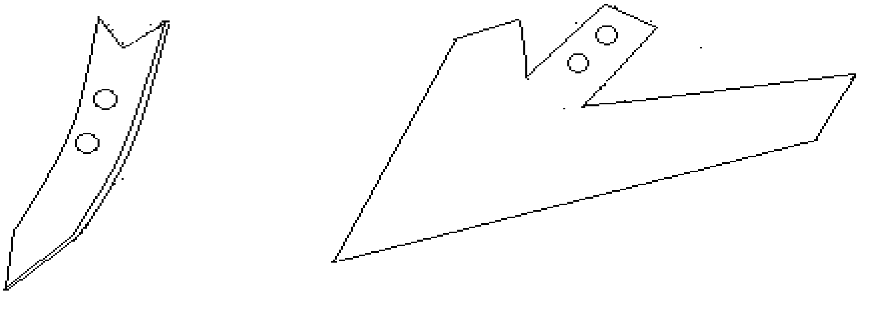

Plate-1. Land preparation

Plate-2. Conventional chisel plow in operation

Plate-3. Modified chisel plow in operation

3. RESULTS AND DISCUSSION

Field time and speed were shown in Table 2 for conventional and modified chisel plow in the two locations. Theoretical field capacity was demonstrated in Table 3 while effective field capacity, field efficiency and fuel consumption rate were demonstrated in Table 3 and in Figures (3,4,5) for two plow designs in two locations. Crop yield was represented in Table 4 and Fig. 6.

Table-2. Effect of chisel design on field time and operating speed

Treatment	Location 1				Location 2			
	T P h	T h	TT H	S Km / h	T P h	T h	TT H	S Km / h
Conventional plow	0.043 [a]	0.005 [a]	0.048 [b]	6.66 [a]	0.037 [a]	0.005 [a]	0.042 [b]	7.20 [a]
Modified plow	0.047 [b]	0.005 [a]	0.052 [a]	5.94 [a]	0.044 [b]	0.005 [a]	0.049 [a]	6.00 [b]

*The values in column share same superscript letter show no significant difference at 0.05 levels according to Duncan's Multiple Range Test.

TP = productive time, T = turning time, TT = total time, S = speed.

Table-3. Effect of chisel design on field capacities, efficiency and fuel consumption rate.

Treatment	Location 1				Second location 2			
	T. F. C (ha/h)	E. F. C (ha/h)	F. E (%)	F. C. R (l/ha)	T. F. C (ha/h)	E. F. C (ha/h)	F. E (%)	F. C. R (l/ha)
Conventional plow	1.000 [a]	0.833 [a]	83.3 [a]	2.00 [a]	1.080 [a]	0.953 [a]	88.2 [a]	2.00 [a]
Modified plow	0.890 [b]	0.769 [b]	86.4 [b]	1.90 [b]	0.900 [b]	0.816 [b]	90.7 [b]	2.00 [a]

*The values in column share same superscript letter show no significant difference at 0.05 levels according to Duncan's Multiple Range Test.

TFC = theoretical field capacity, EFC = effective field capacity, FE = field efficiency, FCR = fuel consumption rate.

Table-4. Effect of chisel design on sorghum crop yield (kg / ha).

Treatments	location 1	Location 2
Conventional chisel plow	1008.7 [a]	1021.3 [a]
Modified chisel plow	1056.4 [b]	1071.4 [b]

*The values in column share same superscript letter show no significant difference at 0.05 levels according to Duncan's Multiple Range Test.

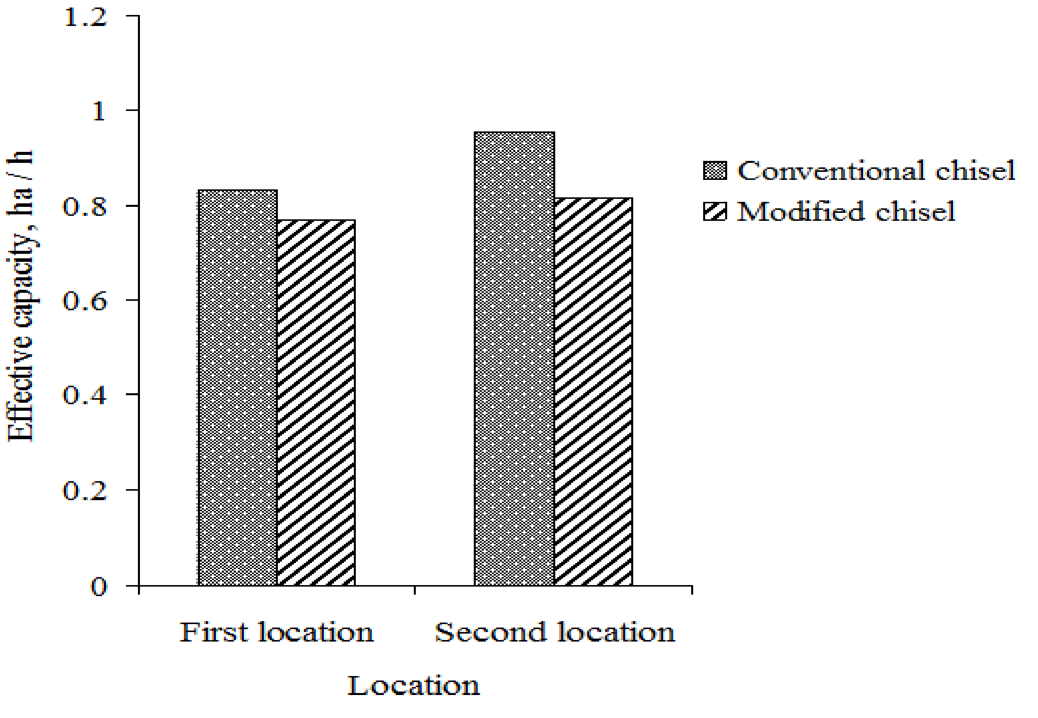

Fig. 3 Effective field capacity

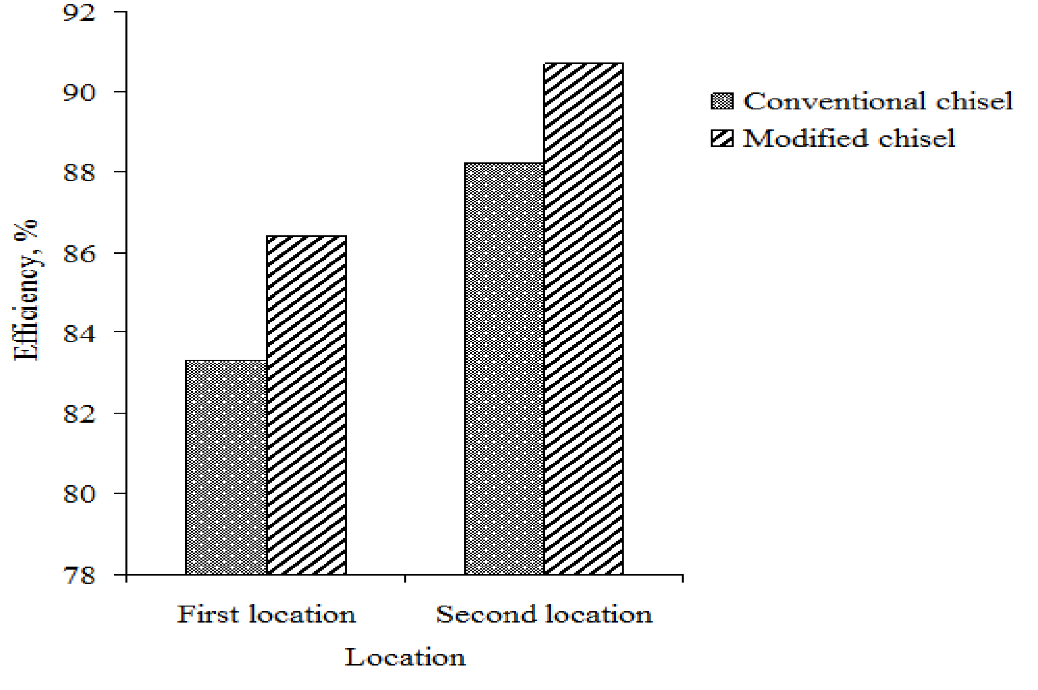

Fig. 4 Field efficiency

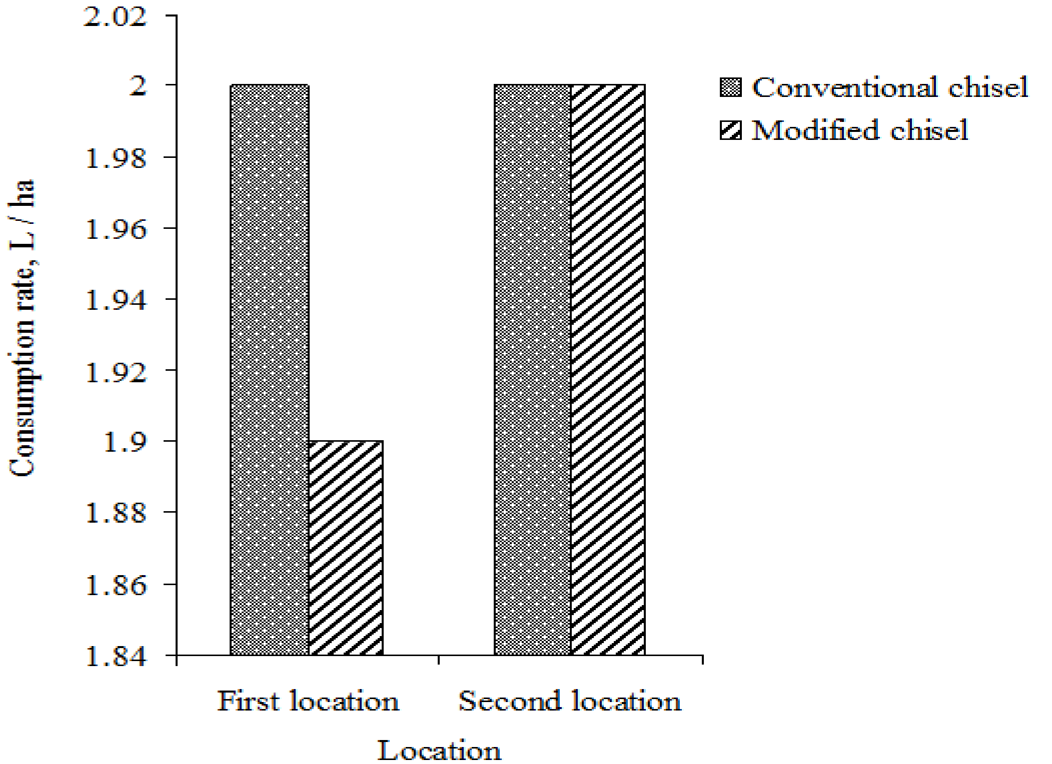

Fig. 5 Fuel consumption

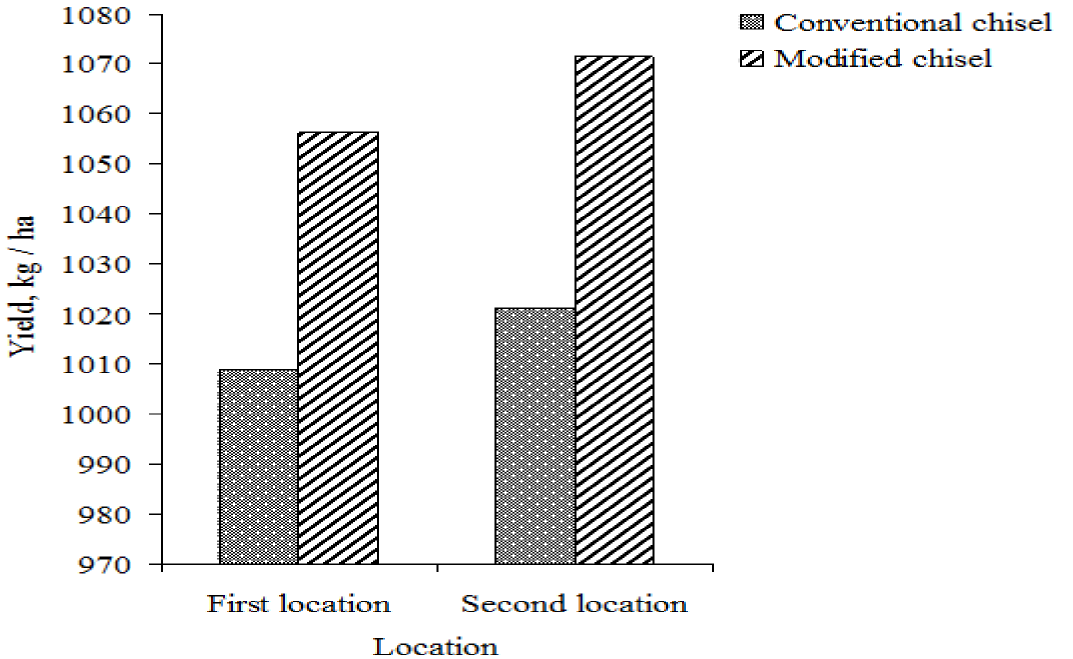

Fig. 6 Crop yield

Table 2 showed that the total field time taken by conventional plow was lower than that taken by modified plow by 0.0044 h and 0.0077 h in the first location and second location: , respectively and there was no significant difference in total field between two implement designs in each location at 0.05 level. Speed value recorded by conventional plow was higher than that recorded by modified plow by 0.72 km / h in the first location and by 1.2 km/ h in the second location and the differences between the two implement designs were significant at 0.05 level.

Table 3 demonstrated that the theoretical field capacity recorded by conventional plow was higher than that recorded by modified plow by 0.11 ha / h and 0.18 ha / h in first and second location: , respectively, and the difference was significant at 0.05 level that was due to higher speed values recorded by conventional plow. The effective field capacity of conventional plow (Table 3 and Fig. 3) was higher than that for modified plow by 0.064 ha / h in the first location and by 0.137 ha / h in second location and the difference between the two designs of plow in each location was significant at 0.05 level.

Field efficiency for conventional plow (Table 3 and Fig. 4) was lower than that for modified plow and the difference between values of field efficiency in each location was significant at 0.05 levels.

Fuel consumption rate recorded by conventional plow was higher than the rate recorded by modified plow by 0.10 L / ha in first location and the difference was significant at 0.05 level, while in the second location no significant difference was recorded in fuel consumption rate between two designs of plow (Table 3 and Fig. 5). The higher fuel consumption rate demonstrated in the first location by conventional plow was due to high speed in the location. Abualgasim and Dahab [19] found that the chisel plow recorded the highest draft, field efficiency, fuel consumption and the lowest field capacities compared to other treatments. The modified chisel plow saved about 23 up to 59% in the power consumption and about 30 up to 58% in the energy requirements compared with other shapes of chisel plow as reported by El-Iraqi, et al. [17]. Majdaldin and Dahab [20] found that chisel plow in loamy sand soil recorded 0.15 ha / h (effective capacity), 0.17 ha / h (theoretical capacity) and 88.24 % field efficiency. On other hands, Lotfie, et al. [21] reported that when a chisel plow operated in heavy cracking clay soil, showed 1.4 ha / h effective capacity and 13 l / h fuel consumption rate. Tayel, et al. [22] found that chisel plow demonstrated higher water use efficiency as compared with moldboard plow

Fig. 6 and Table 4 showed that the crop yield recorded by the conventional plow was lower than that recorded by modified plow by 47.7 kg / ha in the first location and by 50.1 kg / ha in the second location and the different between the plow designs in each location was significant at 0.05 level. The higher yield recorded by modified plow may be due to its wider surface that effectively remove the weed as well as improvement of soil moisture conservation.

4. CONCLUSIONS

A conventional chisel plow was operated in clayey sand soil, and then the rear tools of the plow were replaced with wide winged tools and the plow was then operated in same soil type.

The conventional plow showed higher values of speed, theoretical field capacity, effective field capacity and fuel consumption rate, while the modified plow recorded higher values of field time, field efficiency and crop yield.

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