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Costs and profit analysis for owning and operating of some farm machinery in the Gezira scheme, Sudan

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Abstract

Farm machinery cost is important issue for machinery management. Farmers in the Gezira scheme, Sudan owned several machinery types. Unfortunately, information about their costs and profitability is inadequate. This study aimed at analyzing costs and determining profit for machinery owned by farmers in the scheme. The required data was collected through questionnaire from machinery owners, it included tractor make and implements type, purchase price, annual covered area and work rate. In addition to variable cost items, customer rental rate and driver wage. Ten implements were studied namely; disk plow, chisel plow, moldboard plow, disk harrow, scraper, ridger, ditcher, row planter, seed drill and sprayer. Costs and profit were calculated by using standard procedures. The results showed variations in fixed cost amongst implement. Moldboard plow and scraper obtained the highest and the lowest fixed costs, respectively. The percentage of fixed cost for implement and tractor was between 11% and 28% from total operation cost. Fuel and driver costs were the highest amongst variable cost items, they represented more than 50% of total variable cost. Disk plow and sprayer obtained the highest and lowest total operation cost, respectively. All of the studied implements were profitable and their benefit cost ratio was between 1.5 to 2.7. Row planter and moldboard obtained the highest and the lowest annual net return, respectively. The profitability of machinery in the Gezira scheme may encourage farmers to invest in other machinery types.

Keywords: *Mechanized farm operations, fixed cost, variable cost, benefit cost ratio, private farmers.*

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Introduction

Mechanization of farm operations is important for modern agricultural production. Farm machinery provides timely operation and maintain good quality of work. Moreover, farm machinery is efficient, economical, labor and time saving but its initial cost is quite high, especially for smallholder farmers. For economic use efficiency of farm machinery, it is advisable to provide the highest possible performance with the lowest possible operating costs (Spokas and Steponavicius, 2011). However, there are many factors govern the success of mechanized farm operations; such as crops combination and feature, weather and soil conditions, readiness and management of tractor and machinery as well as economic aspects. The seasonality of crop production makes farm machinery have a few weeks or months a year. Therefore, a certain minimum amount of work must be available to justify ownership of a machine.

Farm machinery costs play an important role in machinery management, selection and decisions. Farm machinery cost represents high proportion of total farm cost (Anderson, 1988; Buckmaster, 2003). Farm machinery costs are usually divided into two groups; annual ownership costs, (fixed costs), and operation costs (variable costs). Fixed cost occurs regardless of machine use whereas operating cost varies with the machine use (Lazarus, 2009). Fixed costs include; depreciation, taxes, insurance, interest and shelter costs. Burton (2005) indicated that fixed costs per unit area vary inversely with the amount of annual use of a machine. Variable costs include; repair and maintenance, fuel, lubricants and labor. Total cost of performing a field operation is the summation of fixed and variable costs for both power source and implement (Kepner, *et al.*, 1982; Hunt, 2001; and William, 2005). Fixed, variable, and total machine costs can be calculated on an annual, hourly, or per unit area basis.

The cost of operating farm machinery varies from machine to another and from country to another according to purchase price, work rate and annual use as well as local prices of fuel, oil, spare parts and labor wages. Some authors worldwide had estimated farm machinery cost for varieties of implements with different scenarios and calculation procedure (Sabir *et al.*, 1990; Mohamed *et al.*, 2018). However, several studies had focused only on repair and maintenance costs of tractor (ASAE, 1989; Bakht *et al.*, 2009**,** Khodabakhshina and Shakeri, 2011, Yousif, 2016, Dahab, *et al.*, 2021) rather than total operation costs of farm machinery.

In the Gezira irrigated agricultural scheme in central Sudan, agricultural machinery is used to perform farm operations for several crops like cotton, groundnut, sorghum, pigeon pea in summer season and wheat, check pea and onion crops in winter season. These operations include land preparation, sowing, weed control and harvesting. There are different types of land preparation machinery. After the Gezira low for 2005 had implemented, some farmers began to own and manage farm machinery to solve the problems of shortage of hand labor, especially during peak demand periods. Investment on a farm machinery requires big funds, which may affect benefit cost ratio, thus farm profitability in the long run. Many questions were a raised about the economics of owning and using machinery in the Gezira scheme; unfortunately, the available information is inadequate, especially for machinery owned by individual farmers. Therefore, providing information on costs, and profit of agricultural machinery is of great necessity for their successfulness and sustainability.

The objectives of this study were to estimate costs and to determine profit for some farm machinery owned and managed by private individual farmers in the Gezira irrigated scheme, Sudan.

Materials and methods

Study area

This study was carried out in the Gezira irrigated scheme, Sudan. The scheme is located between the Blue Nile and White Nile south to Khartoum. The climate is semi-arid and the soil is heavy clay Vertisols. The total area of the scheme is about 2.2 million feddans. Different types and sizes of canals are existed, which deliver irrigation water from Sennar dam to the farms. The farms are arranged in Numbers, each Number size is 90 feddans, which contains several farms. Each Number has to be grown by the same crop or similar crops once time yearly. Each farmer has farm size of about 3 to 4 feddans. Farmers have long experience in managing their farms. Five-course rotation is followed. Several crops are grown in summer and winter seasons each year. Due to technical limitations, 60% of area is planned to be cropped in summer season, 20% in winter season and the remaining area is left as a fallow in the rotation. The summer season starts in June and ends in November, while winter season starts in late October and ends in late March. Tractors of 75 to 80 hp and matched implements type are used to perform necessary operations. Generally, seedbed preparation is the only fully mechanized operation. Several types of primary and secondary tillage implements are intensively used. Other farm machinery such as seed drill, row planter and sprayer are recently introduced, but in fewer numbers compared to tillage implements.

This clearly illustrates the peak and least demand for farm machinery in the scheme during the year.

Data collection

A comprehensive questionnaire was designed and used to collect the required data. The required data was collected from owners of tractors and machinery in the Gezira scheme, during season 2022/2023. 154 tractor owners were responded to the questionnaire. The studied implements were sufficient and representative to existing implements in the Gezira scheme. The collected data included tractor make and implements type, their initial purchase price and annual covered area for each implement. In addition to, the questionnaire included questions about work rate (field capacity), fuel consumption and customer rental rates for each operation. Moreover, data on repair and maintenance costs for tractor and implements and driver wage rate were also included.

Data analysis and calculation procedures

Cost and profit analyses were carried out for 10 types of implements, which were recorded by respondent farmers. These farm machinery were; Disk plow (DP), Chisel plow (CP), Moldboard plow (MBP), Disk harrow (DH), Scraper (SC), Ridger (R), Ditcher (D), Row planter (RP), Seed drill (SD), and Field sprayer (FS). The data for each implement was prepared in a separate excel worksheet. Table 1 shows the estimated parameters and their calculation procedures.

Table 1. Estimated parameters and their calculation procedures

Parameter	Measuring unit	Symbol	Calculation procedure
Implement annual covered area	Fed/yr	IACA	Average value
Implement work	Fed/h	IWR	Average

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rate			value
Implement annual working hours	h/yr	IAWH	= IACA/IWR
Tractor annual working hours	h/yr	TAWH	Equation 1
Tractor initial purchase price	SDG	TIPP	Average value
Implement initial purchase price	SDG	IIPP	Average value
Tractor fixed cost	SDG/fed	TFC	Equation 2
Implement fixed cost	SDG/fed	IFC	Equation 3
Variable cost	SDG/fed	VC	Equation 4
Driver rate	SDG/fed	DR	Average value
Fuel consumption rate	l/fed	FCR	Average value
Fuel price	SDG/l	FP	Average value
Fuel cost	SDG/fed	FC	= FCR * FP
Lubricants cost	SDG/fed	LC	Average value
Tractor R &M cost	SDG/fed	TR&MC	Equation 5
Implement R&M cost	SDG/fed	IR&MC	Equation 6
Total operation cost	SDG/fed	TOC	Equation 7
Customer rental rate	SDG/fed	CRR	Average value
Gross return	SDG/yr	GR	= CRR * IACA
Net return	SDG/fed	NR	= CRR - TOC

Moreover, the following equations were used to calculate the intended parameters.

1. Operation cost: These include annual fixed, for both tractor and implement, and variable costs, they were calculated per feddan (1 feddan = 0.42 ha).

a- Fixed cost of tractor: Tractor fixed cost was calculated in a way that the value of tractor fixed cost decreases as annual hour of use of implement increased.

Tractor fixed cost (SDG/yr) = TPP * % of average annual tractor fixed cost (20.21%)/100

Tractor fixed cost (SDG/h) = Tractor fixed cost (SDG/yr)/TAWH

Tractor annual working hours (TAWH) = summation working hours of implements accompanying tractor …… (1).

Tractor fixed cost (SDG/fed) = Tractor fixed cost (SDG/h) / implement work rate (fed/h)…….. (2).

b- Implement fixed cost (SDG/yr) = IPP * % of average annual implement fixed cost / 100 …….. (3).

Implement fixed cost (SDG/ fed) = Implement fixed cost (SDG/yr) / annual covered area (fed/yr)

c- Variable cost (VC): variable cost includes driver rate, fuel, lubricants costs in addition to repair, and maintenance costs for tractor and implement. These cost items were calculated as follows:

VC (SDG/fed) = DR (SDG/fed) + FC (SDG/fed) + LC (SDG/fed) +TR&MC (SDG/fed) +IR&MC (SDG/fed)……. (4).

TR&MC (SDG/fed) = Annual repair and maintenance expenditure of tractor (SDG/yr)/ [(implement annual working hours (h/yr) * implement work rate (fed/h)]……. (5).

IR&MC (SDG/fed) = Annual repair and maintenance expenditure of implement (SDG/yr)/ implement annual covered area (fed/yr)…… …. (6).

d- TOC (SDG/fed) = [TFC (SDG/fed) + IFC (SDG/fed) + VC (SDG/fed)]…… (7).

2. Percentage of cost items: The fixed and variable costs sub-items were calculated as percentage of the estimated total operation cost and customer rental rate,

Results and discussion

Fixed costs

Table 2 shows the average values of fixed costs for tractor, the selected implements and their total fixed cost per feddan. The results revealed that there were notable differences between the implements in the value of the fixed cost. The fixed cost of the selected implements was between 1545 and 116 SDG/fed. The highest fixed cost was obtained by moldboard plow followed by row-planter, whereas the lowest was obtained by scraper followed by ridger implement. These variations in implements fixed cost may be due to differences in their initial purchase price, work rate and annual covered area. Likewise, there were variations in tractor fixed cost. The fixed cost of the tractor work with the selected implements were between 1639 and 228 SDG/fed. The tractor fixed cost when worked by disk plow gave the highest value followed by moldboard plow, whereas the lowest value was obtained by ditcher followed by row-planter. These variations in tractor fixed cost may be due to differences in tractor initial purchase price, annual working hours in addition to implement work rate and annual covered area. On the other hand, the results showed that the total fixed cost of both implement and tractor varied from implement to another. It is hard to make judgement on the obtained values of fixed costs, because authors did not find any document reported the values of fixed cost in the Gezira scheme for comparison in recent years. However, these values seemed to be reasonable compared to the customer rental rate and total operation cost obtained in this study. The fixed costs items are depreciation, taxes, insurance and shelter. However, in the Sudan, agricultural inputs, like machinery, are tax-exempted and insurance is limited to tractor and combine harvester at getting work license. Moreover, machinery is usually kept in house-yard consequently, shelter cost is not considered in fixed cost items. These mean the obtained values of fixed costs are mainly allotted to depreciation.

Table 2. Fixed costs (SDG/fed) analysis for some machinery operations in the Gezira scheme

Implement	Implement fixed cost	Tractor fixed cost	Total fixed cost
Disk plow	479	1639	2118

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Chisel plow	514	647	1161
Moldboard plow	1545	1229	2774
Disk harrow	1153	362	1515
Scraper	116	307	423
Ridger	236	273	509
Ditcher	202	228	430
Row-planter	1366	246	1612
Seed drill	1114	300	1414
Sprayer	409	137	546

Variable cost

Variable cost items comprise driver cost and repair and maintenance costs for both tractor and implement. In addition to fuel cost and lubrication cost. The results showed that variable cost items varied from machinery to other. Table 3 shows the average values of variable cost items for the studied farm machinery in the Gezira scheme. The results showed that the fuel and driver cost were the highest cost compared to the other variable cost items for all of the selected farm machinery. Irrespective of implement type, these two costs alone represented more than 50% of total variable cost. The highest driver cost was recorded by chisel plowing followed by disk plowing, and scraper and sprayer implement obtained the lowest cost.

The results revealed that the disk plow resulted in the highest fuel cost, lubricant cost, tractor repair and maintenance costs in addition to total variable cost. This indicate that disk plowing obtained the most expensive variable cost among the studied machinery. Moreover, the results revealed that the sprayer obtained the lowest fuel cost, lubricant cost, tractor repair and maintenance costs in addition to total variable cost. This indicate that spraying obtained the cheapest variable cost among the studied machinery. These findings were of great importance to machinery owners in order to prepare the required amount of money to face the expense for their machinery at suitable time.

Table 3. Variable costs (SDG/fed) analysis for some machinery operations in the Gezira scheme

Implement	Driver cost	Fuel cost	IR&MC	Lubricant	TR&MC	Total
Disk plow	2833	4932	590	479	1199	10033
Chisel plow	2890	2700	446	167	448	6651
Moldboard plow	2615	3880	728	268	801	8292
Disk harrow	2524	1875	1442	300	694	6835
Scraper	1040	1597	219	221	428	3505
Ridger	1692	1890	66	116	366	4130
Ditcher	1165	1110	340	70	335	3020
Row-planter	1550	1763	279	120	358	4070
Seed drill	1713	1688	672	14	256	4343
Sprayer	1062	323	297	36	230	1948

IR&MC = Implement repair and maintenance cost, TR&MC = Tractor repair and maintenance cost.

Figure 1 compares variable cost sub-items for the studied implements. It is evident that repair and maintenance costs for implements and tractor were the lowest cost items amongst the variable costs for all the studied implements. This inferred those tractors and implements received careful attention during operations as they took fewer expenses for repairs and maintenance. On the other hand, driver and fuel costs were the highest among the other variable cost items. These findings were useful as they detected and defined what are the more expensive and cheapest variable cost items for machinery operations in the studied area.

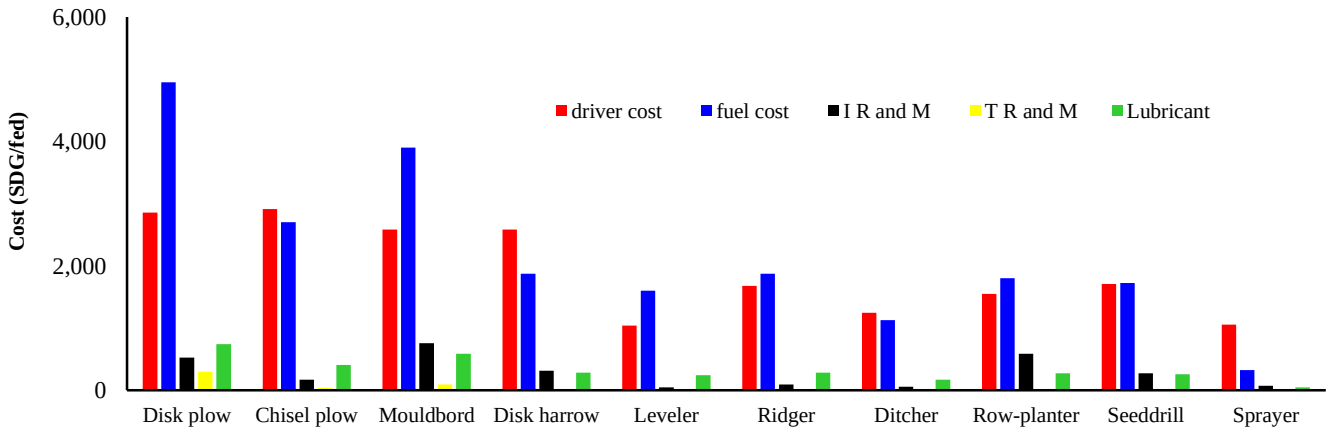

Fig. 1. comparing variable cost (SDG/fed) sub-items for some farm machinery in the Gezira scheme

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Total operation cost

The results showed that the disk plowing resulted in the highest total operation cost followed by moldboard plowing, whereas the lowest total operation cost was obtained by spraying followed by ditching (Table 4). On the other hand, the results showed that the customer rental rate for the studied implements varied considerably; disk plowing was the highest and spraying was the lowest. It seemed that the primary tillage implements has the highest customer rental rate compared to the other implements. This may be due to their high fuel consumption rate and lower work rate.

The results showed that all of the studied implements were profitable, as indicated by the obtained values of benefit cost ratio. Sprayer obtained the highest benefit cost ratio (2.7) and the lowest (1.5) was obtained by moldboard plow (Table 4).

Table 4. Total operation costs, customer rental rate, net return and benefit cost ratio for some machinery operations in the Gezira scheme

Implement	Total operation cost (SDG/fed)	Customer rental rate (SDG/fed)	Net return (SDG/fed)	Benefit cost ratio
Disk plow	12151	19029	6878	1.6
Chisel plow	7812	16749	8937	2.1
Moldboard plow	11066	16667	5601	1.5
Disk harrow	8350	17222	8872	2.1
Scraper	3928	7983	4055	2.0
Ridger	4639	8567	3928	1.8
Ditcher	3450	7357	3907	2.1
Row-planter	5682	12000	6318	2.1
Seed drill	5757	11375	5618	2.0
Sprayer	2494	6846	4352	2.7

Table 5 shows the percentage of cost items from total operation cost. For all implements driver and fuel cost represented more than 50% from total operation cost. Lubricants obtained the lowest percentage among the other cost items for all of the studied implements. The percentage of repair and maintenance for tractor and implements were moderate compared to the percentage of other cost items. On the other hand, the percentage of total fixed costs of tractor and implement from the total operation cost was between 11% and 28. These findings are useful information that can help in estimating the operation cost, especially in cases of changing one of the cost items such as fuel price and driver rate.

Table 5. Percentage of costs items from total operation cost for some machinery operations in the Gezira scheme

Implement	Driver	Fuel	IR&MC	TR&MC	Lubricant	IFC	TFC
Disk plow	23	41	5	10	4	4	13
Chisel plow	37	35	6	6	2	7	8
Moldboard	24	35	7	7	2	14	11
Disk harrow	30	22	17	8	4	14	4
Scraper	26	41	6	11	6	3	8
Ridger	36	41	1	8	3	5	6
Ditcher	34	32	10	10	2	6	7
Row-planter	27	31	5	6	2	24	4
Seed drill	30	29	12	4	1	19	5

IR&MC = Implement repair and maintenance cost, TR&MC = Tractor repair and maintenance cost, IFC = Implement fixed cost, TFC = Tractor fixed cost.

Table 6. Percentage of cost items from custom rental price for some farm machinery operations in the Gezira scheme

Implement	Fuel	Driver	IR&MC	TR&MC	Lubricant	IFC	TFC
Disk plow	26	15	3	6	3	3	9
Chisel plow	16	17	3	3	1	3	4
Moldboard	23	16	5	5	3	9	7

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Disk harrow	11	15	5	5	2	7	2
Scraper	20	13	3	7	3	1	4
Ridger	22	20	1	5	1	3	3
Ditcher	16	17	5	5	1	3	3
Row planter	15	13	2	3	1	11	2
Seed drill	15	15	6	3	2	10	3
Sprayer	5	15	4	4	1	6	2

IR&MC = Implement repair and maintenance cost, TR&MC = Tractor repair and maintenance cost, IFC = Implement fixed cost, TFC = Tractor fixed cost.

Profit analysis

Table 7 illustrates the average values of parameters involved in profit analysis for the studied farm machinery operations in the Gezira scheme. The results showed that all the studied farm machinery were profitable, however, there were substantial variations between the studied farm machinery in annual net return. The annual net return was ranged between SDG 683285 and SDG 2843100. The revealed that the highest annual net return was obtained by row-planter followed by disk harrow. The lowest annual net return was obtained by moldboard plow followed by sprayer. The variations between the studied farm machinery in annual net return could be attributed to differences in customer rental rate, annual covered area and total operation cost. The profitability of the farm machinery may encourage farmers to invest on other machinery such as inter row cultivator and crop residues management machinery. As this study deal with average data for each implement, therefore, other studies are suggested to investigate the effect of number of machinery fleet and their annual performance on the total net return.

Table 7. Analysis of profit (SDG/yr) for some farm machinery operations in the Gezira scheme

Implement	Covered area (fed/yr)	Gross return (SDG/yr)	Total operation cost (SDG/yr)	Net return (SDG/yr)
Disk plow	220	4186380	2673220	1513160
Chisel plow	180	3014820	1406160	1608660
Moldboard	122	2033337	1350052	683285
Disk harrow	274	4718828	2287900	2430928
Scraper	319	2546577	1253032	1293545
Ridger	365	3122672	1690916	1431757
Ditcher	296	2177761	1021200	1156561
Row-planter	450	5400000	2556900	2843100
Seed drill	261	2968875	1502577	1466298
Sprayer	194	1328163	483836	844327

Figure 2 compares profit per hour and profit per feddan for the studied implements. The tillage implements namely disk plow, chisel plow, moldboard plow and disk harrow obtained higher profit per feddan than per hour. The reverse was true for the rest of the studied implements. It was observed that as work rate of an implement increased the profit per hour increased too. These findings help investors (the farmers) to select implements that realize higher profit.

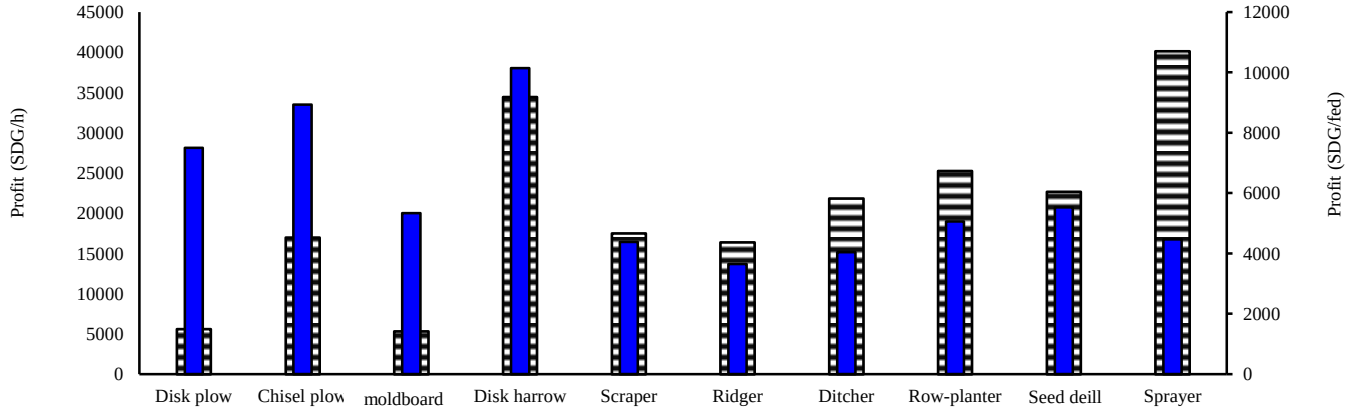

Fig. 2. Comparing profit (SDG/h) versus profit (SDG/fed) for some farm machinery in the Gezira scheme

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Conclusion

- The study analyzed the cost and profit per unit area for ten implements that owned by private farmers and worked in the Gezira scheme. The studied implements were; disk plow, chisel plow, moldboard plow, disk harrow, scraper, ridger, ditcher, row planter, seed drill and sprayer.
- Fixed costs for both implement and tractor varied considerably from implement to implement. Moldboard plow and scraper obtained the highest and lowest fixed cost per unit area, respectively. The percentage of fixed cost for both implement and tractor from total operation cost was ranged between 11% and 28%.
- The fuel and driver costs were the highest cost compared to the other variable cost items for all of the studied farm machinery. Irrespective to implement type, these two costs alone represented more than 50% of total variable cost.
- The disk plowing resulted in the highest total operation cost followed by moldboard plowing, whereas, the lowest total operation cost was obtained by sprayer followed by ditcher.
- All of the studied farm machinery were profitable and their benefits cost ratio were between 1.5 and 2.7. However, there were substantial variations between the studied farm machinery in annual net return. The highest annual net return was obtained by row-planter followed by disk harrow and the lowest was obtained by moldboard plow followed by sprayer.
- The profitability of machinery in the Gezira scheme may encourage farmers to invest in other machinery types, such as inter row cultivator and crops residues management machinery.

Interest of conflict

The author has not declared any conflict of interest

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