Crop-Machinery Management System For Farm Cost Analysis

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Abstract: Assessment of the total costs of agricultural farm is important to decide for selection of optimum combination of machinery, crops and farming system that can maximize profit. The decision on optimum combination of these factors by customary way is quite difficult due to their natural complexity. A computer system was develop in Excel-Visual basic software for farm management decision making, and to estimate machinery and the whole farm costs and net return from crops grown under different farming systems. The system deals with four crops and three farming systems by using tractor and six machines. The input data includes: crops type, operations, machine and inputs cost. The system was verified, validated, analyzed and its accuracy was approved. The system outputs change with various input parameters like farm size, machines used and crops combination. Application of the system showed that annual working hours, size and age of machines affect the fixed and total operation costs. The least operation cost was obtained by conventional farming system followed by zero tillage and heavy machinery system. Different crops varied in their costs when grown alone or in combinations in different farming systems. The lowest and highest net returns were obtained by growing sorghum alone with heavy machinery farming system and by growing the four crops in Zero-Tillage farming system. The system can be used as pre-season planning and management decision tool.

Index terms: computer system, machinery costs, farm costs, rainfed areas, decision tool

1. INTRODUCTION

Crop production involves sequence of operations; where several machines, crops, management practices, inputs costs and other factors get together and influence productivity, total costs as well as final net return. Modern crop production involves quick and correct decisions coupled with high level of technical management to improve productivity, minimize production cost and to maximize profit. Optimal crops and machinery combination are essential for a successful farming system. Selection of optimum machinery size, crops combination and cropping system is an important at the same time is complex management issue. Farm machinery cost represents high proportion of total farm cost [1], [2]. It includes ownership cost, which occurs regardless of machine use, and operating cost, which vary with the machine use as well as penalties for lack of timeliness [3].

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On the other side machinery costs are of especial important when considering technological changes. Besides affecting machinery buying and trading decisions, machinery costs affect profit-maximizing crop and rotation selection, thus long-run farm profitability. In addition to machinery costs other farm costs is necessary for the whole farm cost analysis. *Computers have become increasingly accepted as farm management tools to assist decision-making. A lot of publications showed that computer programmes were used successfully to select farm machinery, to estimate their costs as well as to estimate the whole costs [4], [5], [6], [7], [8], [9]. Yousif (2011) [10] developed a computer system to be used as a tool for crops -machinery system management to select the number and size of machinery required to perform a timely seedbed preparation, seeding and weeds control operations. This system uses six implements, for four crops grown singly or in combination and three farming systems.* The objective of this study was to develop a computer system for farm management and decision making. The aim of this system was to estimates machinery and whole farm costs and net return for crops grown under different cultivation systems.

2. MATERIALS AND METHODS

2.1. Crops grown and machinery used in the studied area

Sorghum is the dominant grown crop in the mechanized rainfed areas eastern Sudan, followed by sesame, while sunflower and cotton are sown in limited areas where rain amount is sufficient for their growth. No definite crop rotation is followed. The mechanized system consists of farms of 360 to 420 ha or more. Tractors of 75-80 hp are the main source of farm power; however, recently large tractors were introduced for improving timeliness of agricultural operations. According three farming systems are used, the conventional farming system which uses wide level disk for seedbed preparation and seeding and sprayer for weed control, zero-tillage farming system that uses sprayer and row crop planter and the heavy machinery farming system uses chisel or disk harrow for seedbed preparation, row crop planter and sprayer.

2.2. Collected data

The collected data to run the system include; crop and machinery data, as well as related costs and prices. Crop data included crop type, area, management practices, yield and yield value. Machinery data included type and size of machine, field efficiency, speed, draft requirement, repair and maintenance cost percentages, machinery capacity, fuel consumption rates, and fuel cost and machines prices. These data were collected from many sources, such as engineers and farm manager in Gedarif mechanized rainfed agriculture, field observations, Mechanized Farming Corporation (MFC), Sudanese Agricultural Bank, ASABE standard, John Deer publications, and Agricultural Machinery dealers.

2.3. Computer system development

The system was developed in Excel-Visual basic computer software. Data entry is a step by step process in the designed cells. Data input may be corrected directly on screen. The system output can be displayed on the screen or as print out. The crop and machinery management system was designed to work with a sequence of units working collectively. Crop and implement selection unit is the basic procedure for the whole programme, which allows the user to choose crops and intended field operations. Field operations and machinery selection unit computes the total area for each crop and each implement; determines the size and numbers of machinery, matches implement with tractor power and estimates fuel consumption. Farm cost analysis unit calculates machinery costs, and other farm costs, it also estimates net return per hectare for single or multi crops grown in any of the mentioned cropping systems.

2.4. Theoretical Calculations

Machinery cost calculation

Machinery cost include tractor and implement cost
Fixed cost (FC) per hour was calculated as follows:

FC = (FC% P / AWH)* 100 ……..………………... (1)

Where: FC% = percentage fixed cost, P = price and AWH = annual working hours

Running cost calculation

Running costs (RC) per hour include fuel, oil, repair and maintenance and labor costs; were calculated as follows:
Fuel consumption (FC) for diesel engine is calculated as follows:

FC (L/hr) = Drawbar horse power (KW) x 0.226 … (2)

Fuel cost (SDG/hr) = Fuel consumption (L/hr) x Fuel cost (SDG/L) …… (3)

Oil cost is calculated as percent of fuel cost as follows:

Oil cost (SDG/hr) =Fuel cost (SDG/hr) x 0.15 ….. (4)

Repair and maintenance cost was computed as percentage of purchase price as follows:

R&M cost (SDG/hr) =(R&M% P) / (100 x annual hours of use)……….. (5)

Where: R&M% = percentage of repair and maintenance cost

Labor cost is computed per hour and the charge is taken according the current local usage rate.

Tractor total running cost (TRC) is calculated as follows
TRC/hr = FC + OC + R&M cost +LC …………... (6)

Tractor total cost (TTC) is the sum of fixed and running costs and it was calculated as follows

TTC = TFC + TRC …………………………. (7)

Annual hour for an implement was calculated as follows:

AWH = (CF x A) / SWE …………….……... (8)

Where: CF = correction factor, constant = 10, A = area under operation, ha, S = forward speed, Km/hr, W = effective width, m and E = field efficiency, decimal If the machine is used for more than one operation its annual working hours is the summation of the working hours of each operation. Implement total cost (ITC) is the sum of fixed cost and repair and maintenance cost and was calculated as follows:

ITC = IFC + I R&M …………………….. (9)

The total cost for a field machine is the sum of tractor & implement total costs that can be expressed as

AC = TTC+ ITC …….…………………. (10)

Farm costs analysis

Farm cost analysis includes estimation of total costs, total income and net return for single or multi crop combinations. The three costs calculated were inputs, farm operations and other costs. Input cost(IC) could be calculated by the following equation:

IC = A (LR + SC + STC + HC + HTC + FWC) .. (11)

Where:

A = area, hectare, LR = land rent cost/ha, SC = seed cost/ha, STC = seed treatment cost/ha, HC = herbicide cost/ha, HTC = hand tools cost/ha and FWC = food & watering cost/ha

Farm operation cost (FOC) was calculated by the following formula

FOC = SBOC + SOC + WCC + HWD + HC) ……. (12)

Where:

SBOC = seedbed operation cost, SOC = seeding operation cost, WCC = weed control cost, HWC = hand weeding cost and HC = harvesting cost.

Other costs (OC) include Zakat and farm management costs were determined as follow:

OC = A (0.1 CV x CY + MC)……………..... (13)

Where: CV = crop value, SDG/Kg, CY = crop yield, Kg/ha and MC = management cost, SDG/ha

The total farm cost is the sum of input, operation and other cost.

Total income (TI) is calculated as follows:

TI = A (CY x CV + BPV) …………………… (14)

Where: SDG and BPV= by-product value, SDG/ha

Net return (NR) was calculated as follows:

NR = TI – TFC……………………..….. (15)

3. RESULTS AND DISCUSSIONS

The system verification showed that as soon as entering the required input data the system displays the output results, indicating that the system can easily calculate the designed parameters.

3.1. Machinery costs analysis

The system was used to analyze machinery cost with respect to annual working hours, age and size of tractor and implements singly or in combinations. The results of changing tractor and WLD annual working hours are presented in Table 1. For example, increasing annual working hours from 162 hrs to 594 hrs the fixed cost and total operation cost in Sudanese Guneh per hour (SDG/h) were decreased by about 73% and 71% and 73% and 66% for tractor and WLD, respectively. This means that the annual working time affects the costs of machinery. The system was also used to examine the effect of changing implement width on costs. The results of changing the width of WLD, chisel plow and row crop planter are presented in Table 2. The obtained results indicated that the small width of the three machines resulted in the lowest costs (SDG/h and SDG/ha), this mainly due to the initial purchase price of the small size machines. Table 3 shows the effect of changing the size and age for tractor and WLD. The results showed that as the size of tractor increased the fixed and operation costs (SDG/h) increased. However, as the age of tractor increased the fixed and operation costs (SDG/h) decreased. The same things happen for the case of WLD.

3.2. Farm costs analysis

The system allows the user to use any set of the programmed machines and farming system. Three framing system were tested, namely; conventional, zero-tillage and heavy machinery farming systems. The results showed that conventional farming system gave the smallest values of power required, fuel consumed as well as operation cost per hour and per hectare (Table 4). These findings explain why farmers are still hold on to conventional cropping system. In contrast, heavy machinery system resulted in the highest values of the mentioned parameters. Alam, et al (2001) [9] found that optimum power level varied with the size of farmland and cropping patterns. Also results revealed that zero tillage is profitable and can be implemented if all requirements for its successes are secured. Generally, machinery operation costs increased from conventional framing system to zero tillage to heavy machinery farming system. These results can help the user in pre-season planning and management. The system was also used to study the effect of crops combinations and cropping system, of a farm of 420 hectares, on farm costs, and net return. Result in Tables 5 shows that crops varied in their costs when grown alone or in combinations and in different farming systems. The least total cost (337 SDG/ ha) was obtained by sunflower when grown alone in conventional farming system, whereas the highest total cost (1739 SDG/ha) was obtained by cultivating the four crops in heavy machinery farming system. These variations in total costs probably are due to the used machinery and their associated costs and the costs of the other inputs. On the other hand, the final net return varied according to crops and farming system (Table 6). The lowest and highest net return were 114 and 1516 SDG/ha was obtained by growing sorghum alone in heavy machinery farming system and the four crops in Zero-Tillage farming system, respectively. These results demonstrated that more crops in a farm will increase the net return; however, these results are inline with the findings of [8]. These out puts help the farm manager to select the best crop(s) and cropping system that realize the farm goals. This means that the system can help in saving time and managing and reducing risks that may occur due to miss selection of crops combination.

System application

It is obvious that changing input variables can be easily changed and their effect on system outputs can be detected without need for experiments in the field, therefore, a lot of studies related to machinery selection and management can be carried out. Also the user can employ this system to determine the required set of machinery and hence he can decide on their required services cost, fuel quantity and operators. Moreover, the user can select the optimum crop combination and cropping system that suitable to his farm conditions, input costs, output prices and available resources. Beside that this system can be used as a training tool for under graduated student studying in agricultural engineering institutes. On the other side, if each of the comparisons made by the system to be tested in reality large amount of resources (money and time) and risk (infrastructure and people) will be needed.

4. CONCLUSIONS

A computer system for crop-machinery system management was developed. It is user-friendly and could be run on most available computers. The system was validated, analyzed and its accuracy was proved. The system can quickly be used to explore the effect of changing one or more of input parameters on output variables. Application of the system showed that annual working hours, size and age of the machine and tractor affect the fixed and total farm operational costs. The least machinery operation cost was obtained by conventional framing system followed by zero tillage and heavy machinery farming system. Different crops varied in their costs when grown alone or in combinations and in different farming systems. Growing sunflower alone in conventional farming system gave the least total cost while growing the four crops in heavy machinery farming system gave the highest cost. The lowest net return was obtained by growing sorghum alone in heavy machinery farming system. The highest net return was obtained by growing the four crops in Zero-Tillage farming system. The more crops in a farm will increase the net return. The system can be used as pre-season planning and management decision tool.

5. REFERENCES

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Table 1. Effect of changing annual hours on tractor and WLD costs

Annual working , Hours	Tractor costs (SDG/h)		WLD costs (SDG/h)	
	Fixed	Operation	Fixed	Operation
162	143.5	161.5	80.6	268.8
216	107.6	121.7	60.4	209.9
270	86.1	97.9	48.3	170.8
324	71.8	82.0	40.3	147.9
378	61.5	70.6	34.5	128.8
432	53.8	62.1	30.2	116.9
486	47.8	55.5	26.9	105.5
540	43.1	51.8	24.2	99.9
594	39.1	47.3	22.0	92.1

Using total area of 1260 ha for WLD

Table 2. Effect of changing implements width on implements costs

Machine Name	Width (m)	Cost SDG/h	Cost SDG/ha
	3.7	123.1	46.2
WLD	4.2	147.8	48.9
	5.0	274.8	76.4
	1.3	67.5	76.4
Chisel plow	1.9	96.2	74.5
	4.8	352.2	107.9
	3.2	139.8	74.7
Row crop planter	4.8	273.8	79.5
	6.4	436.4	116.6

Table 3. Effect of changing size and age of tractor and WLD on costs (SDG/h)

Tractor				*WLD*		
Age, years	Size (KW)	Fixed cost	Operation cost	Size (m)	Fixed	Operation
1		181.8	203.8	3.7	26.9	53.0
3		89.6	111.7		12.9	39.1
5	123	69.0	91.0		9.7	35.9
7		58.8	80.8		8.0	34.2
9		52.2	74.2		6.9	33.1
1		124.4	140.3	4.2	32.2	60.7
3		61.3	77.2		13.5	43.9
5	89.5	47.2	63.1		11.6	40.0
7		40.2	56.1		9.6	38.0
9		35.7	51.6		8.3	36.7
1		57.4	66.1	5.0	38.7	69.8
3		28.3	37.0		18.6	49.6
5	55.1	21.8	30.5		13.9	45.0
7		18.6	27.2		11.5	42.6
9		16.5	25.1		9.9	41.1

Annual working hours = 468 and 486 for tractor and WLD, respectively.

Table 4. Effect of cropping system on tractor operations cost

Cropping system	Tractor annual working hours	Fuel consumption (L/ha)	Power required (KW)	Operation Cost (SDG/h)	Operation Cost (SDG/ha)
ZTFS	310	12	52	394.1	122.8
CFS	468	11	51	123.1	46.2
HMFS	589	13	58	494.9	178.9

ZTFS = zero tillage farming system, CFS = conventional farming system, HMFS = heavy machine farming system

Table 5. Effect of crop combination and cropping system on total cost (SDG/ha)

Crop combination and crops name	Cropping system		
	ZTFS	**CFS**	**HMFS**
Sorghum	386	380	421
Sesame	476	483	513
Sunflower	352	337	387
Cotton	367	373	403
Sorghum + sesame	882	917	955
Sorghum + sunflower	737	809	809
Sorghum + cotton	753	776	824
Sesame + sunflower	848	822	921
Sesame + cotton	863	837	936
Sunflower + cotton	719	730	790
Sorghum + sesame + sunflower	1230	1247	1330
Sorghum + sesame + cotton	1245	1273	1345
Sorghum + sunflower + cotton	1104	1115	1211
Sesame + sunflower + cotton	1211	1175	1311
Sorghum + sesame + sunflower + cotton	1592	1620	1739

ZTFS = zero tillage farming system, CFS = conventional farming system, HMFS = heavy machine farming system

Table 6. Effect of crop combination and cropping system on net return (SDG/ha)

Crop combination and crops name	Cropping system		
	ZTFS	**CFS**	**HMFS**
Sorghum	150	156	114
Sesame	600	593	563
Sunflower	184	199	148
Cotton	593	587	557
Sorghum + sesame	731	696	657
Sorghum + sunflower	334	262	263
Sorghum + cotton	743	720	672
Sesame + sunflower	765	790	691
Sesame + cotton	1174	1199	1100
Sunflower + cotton	777	765	706
Sorghum + sesame + sunflower	919	901	818
Sorghum + sesame + cotton	1327	1299	1227
Sorghum +sunflower + cotton	927	917	820
Sesame + sunflower + cotton	1362	1397	1261
Sorghum +sesame + sunflower + cotton	1516	1488	1369

ZTFS = zero tillage farming system, CFS = conventional farming system, HMFS = heavy machine farming system