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A COMPUTER PROGRAM FOR AGRICULTURAL MACHINERY SELECTION

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ABSTRACT: *A computer program for Agricultural Machinery Management (APAMAS) is a user-friendly interactive program written in Excell spreadsheet for machinery management .The user interacts with it by entering the required input data and it will carry out the interactive calculations. The APAMAS can determine the effective field capacity and field efficiency for some tillage implements , determines the drawbar power needed for each implement (hp), The program predicts the number of tractors and implements required for each agricultural operation , calculates the total operation cost(SDG) per fed, and finally giving the user an option to hire or own the machine(BEP). The program enables the user to print out the output which is displayed on the screen. APAMAS was successfully verified statistically in comparison to Giad Company for Agricultural Services-(Eldamer) existing machinery program . The comparisons indicated that there were no significant differences. Validity and sensitivity tests of the program indicated that the APAMAS could be applied to any real-life case successfully and with confidence for any multi- crop farm.*

KEYWORDS: Machinery Management, Effective Field Capacity, BEP, Drawbar Power, Verification, Validation.

INTRODUCTION

Farm machinery contributes a major capital input cost in most agricultural business since it is a major component of any agricultural planning and development strategy in many countries. Agricultural machinery is a major component of agricultural businesses and agricultural development programs. It offers several improvements to farming system in increasing land and labor productivity, saving time and reduction of risk. (Ruiyin, *et al* 1999).

Agricultural machinery management is the section of farm management that deals with the optimization of the equipment phases of agricultural production. It is concerned with the efficient selection, operation, repair and maintenance, and replacement of machinery. Machinery selection of power units and their machinery complements for farming operations, which is important part of machinery management decision, can lead to profit or loss of all or part of the farm enterprise. Therefore, the right choices of equipment coupled with its rational use are extremely important decision-making factors in farm management. (Wenging, *et al*, 1999).

Efficient machinery requires accurate machine performance data in order to meet projected work schedules and to form balanced mechanization system by matching the performance separate

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times of equipment .(Mohamed 2016) . The optimum farm power machinery component is achieved through combination of tractor power required for single operation, the machine size and number of tractor needed to complete field operation at optimum time. Machinery cost are one of the few costs that good management can minimize and learning how to accurately estimate machinery costs will aid in cutting costs .accurate cost estimate play an important role in every machinery management decision (John deer1987).

The main aim of management studies is to complete a certain field operation effectively, during a specific period of time, and at a minimum total cost. With the computer becoming more appropriate and available, the complexity of the farm machinery problem had led some scientists to develop several programs to assist farm managers in decision making about how to manage their machinery efficiently and effectively.(Noble and Course1993) . These programs may be categorized as spreadsheets for agriculture and are being used to assist in decision making about how to manage and select machinery effectively .They are most useful when there is an interaction exchange of information during program operation between the computer and the program user (Mohammed, 2007). Ismail (1994, 1998) developed Crop Production Machinery System (CPMS) model to predict the machinery requirements and to determine the cost of production. For cost analysis he concluded that multiple crops in a rotation will increase machinery and tractor utilization, and reduce costs. The results of the model also show that there was savings of costs if the full cultivator was used in a multiple crops operation rather than for single cropping farm.

In Sudan, one of the pioneer models is that developed by Boll (1996) for matching of a single tractor power and optimum implement size. This was followed by a series of master thesis at Universities of Khartoum and Gezira (Bakri, 1993), for developing programs for estimating cost of mechanized operations based on cost theories. Modeling of machinery management in multi-farms was made by Massoud (2005) for estimating the size of the required machinery fleet on basis of predicting available working days. In 2007 Hag Ali adopted Primavara program to schedule and select agricultural machinery in multi-farm fields. However, in these two models the estimated size of needed machinery is not the optimally required size. Mohammed (2007) develops a decision aid model for agric. machinery management. The model can generate optimum machinery set at minimum total costs using LP technique. The program developed in this study, is a user–friendly interactive program. It estimates machinery performance of some farm tillage implements to determine the effects of the operating parameters when using or choosing farm equipment to help the manager of the farm or scheme to take the correct optimum decisions in managing agricultural machinery and equipment.

In most of irrigated and rain-fed schemes in Sudan there is a lack of machinery reliable data system concerning tractor power utilization, definite costs determination approach and there is no actual complete information of machinery field performance. Computer modeling in Sudan was recognized by some researchers regarding, machine cost and power matching however, these models that deal with all aspects of machinery management are not in one software program, this program is directed to manage all aspects of machinery management in one software model to aid in decision –making process in order to improve multi- farm system .

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The general objective of this paper is to develop an integrated, decision-making aid, computer program for farm machinery management, by determining the field performance of some tillage implements.

The specific objectives of this study are as follows:

1 - To develop a program for predicting technical performance of some tillage implements by determining their productivity aspects (effective field capacities ,and field efficiency) .

2 - To compute the number of tractors and implements .

1- To determine draw bar power for selected implements.

2- To calculate the operation cost per fed

5- To determine whether to own or hire the implement and the tractor (BEP).

MATERIALS AND METHODS

Program Development: *(*Main functions and features):

A computer program for Agricultural Machinery Selection (APAMAS) was developed as an interactive user friendly program, where the users enter input data via a sequence of button driven menus. The user has the option of entering his own choice of data when available. In this case, data is entered in special fields or text boxes which are linked to other fields through equations for data processing.

APAMAS consists of machinery programming section and machinery cost section. The computer program main functions are: To compute the effective field capacity (fed/hr) and field efficiency (%.) for some tillage implements from the user input data, Predicts the number of tractors and implements required for each agricultural operation, Determines the drawbar power needed for each implement (HP), and finally calculates the total operation cost per fed, and gives the user an option to hire or own the implement (Fig.1).

The user is requested to enter input data in tabular format directly from the screen in two forms: 1.technical data, 2.economical data. The second step the user enter the agricultural operation (chiseling, discing , harrowing , leveling and Ridging,), in any operation the user must enter implement and tractor data and then the program will calculate the following parameters:-

i. Effective Field Capacity(fed/hr) by the following formula:

$$EFC = \frac{SWE}{C} \quad \ldots\ldots\ldots \quad \ldots(1)$$

Where: EFC= effective field capacity, S = speed km/h, W: width (m), E:efficiency(%), C: constant (4.2).

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Field Efficiency = Effective Field Capacity * 100% … ……. (2)

Theoretical field capacity

ii. Draw Bar Power (hp) :

$$DBP = \frac{DXS}{375(3.6)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad \ldots\ldots\ldots\ldots(3)$$

Where: D= implement draft (kn) or lb., S = travel speed (km/hr) or mph.

iii. Number of tractors and implements required

$$= \frac{operation\ total\ area}{\text{no of hrs x effective field capacity}} \quad (4)$$

iv. Break Even Point ($BEP(ha) = \frac{\text{total annual fixed cost}}{\text{hiring rate(SDG/ha)} - \text{variablecost(SDG/ha)}}$ ……(5)

v. Operation Total Cost(fed): $OTC = Machine\ Total\ Cost + Tractor\ total\ cost$

Data collection and analysis:

The required built-in primary data for this program was collected using formal and personal contacts with individual agricultural engineers, from Giad Company for Agricultural Services- (Eldamer). The secondary data was collected from bulletins, operation manuals and specifications sheets of machinery and tractors, agricultural operations scheduling program and internal periodical routine reports. The data given was for the season 2015 -2016. Other secondary data was collected from the most relevant published national and international data and periodicals. The main source data were the ASAE yearbook (1991), (1993) and Hunt (1993),) , Descriptive statistical techniques were used to analyze the program results using "SPSS-16" software mainly (T-test).

RESULTS AND DISCUSSION

APAMAS Verification: Verification aims to discover facts about the system under consideration in order to explain its structure and operation .To test program validity it is preferable to employ statistical tools for comparison and judgment. Usually verification is made against established target such as published program or models or accepted field or research data. The APAMAS output was compared to the applied machinery system of Giad Company for Agricultural Services- (Eldamer), season 2015- 2016. APAMAS was succeeded to determine the effective field capacity of the chisel plough , standard disc plough , disc harrow , scraper and ridger which are3.54 , .13, 3.28, 6.32 and 5.46 fed/hr respectively . The results showed that these values for effective field capacity predicted by the program were identical to those of the Giad Company for Agricultural Services machinery system. Also APAMAS estimates the number of tractors for all agricultural operations (Table 1). These values for number of tractors predicted by

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the program were identical to those of the Giad Company for Agricultural Services machinery system.

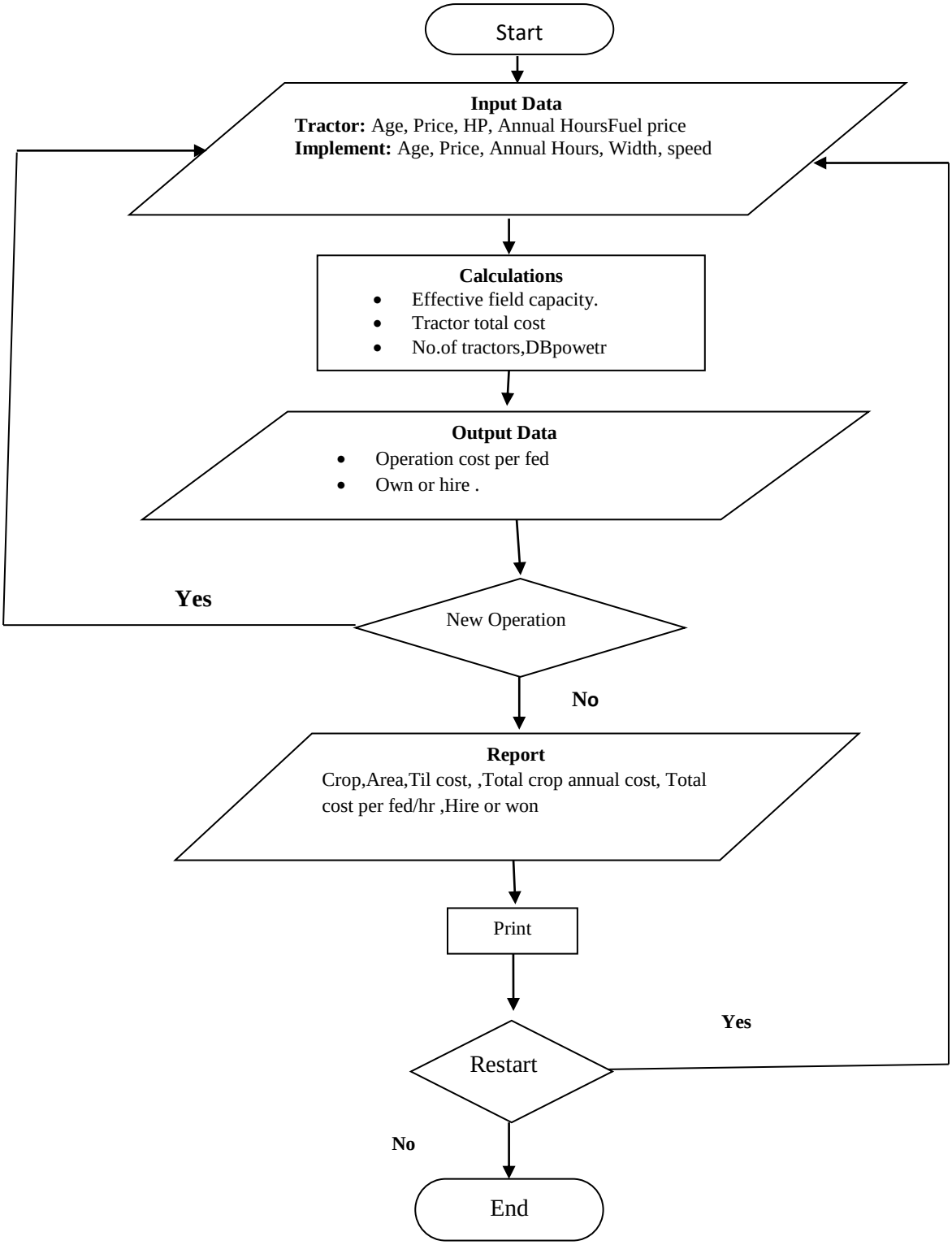

Fig. 1 The computer program flow chart

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Table (1) Effective field capacity and number of tractors for tillage implements

Parameters	Giad Company		APAMAS	
	E F C (fed/hr)	No. of tractors	E F C (fed/hr)	No. of tractors
Chisel plough	3.43	1	3.54	1
Disc plough	1	5	13	5
Disc Harrow	3.5	1	3.28	1
Scraper	6	1	6.32	1
Ridger	5.5	1	5.46	1

APAMAS Validation:

Validation of the computer program refers to study of model effectives or its suitability for satisfying the purpose for which it is built (summers et al, 1999).This can be achieved by comparing model output with machinery system of Giad for Agricultural Services- (Eldamer), The analysis will take the costs of depreciation, interest rate, repair and maintenance costs, and fuel cost per hour for two sizes of tractors mainly, 85HP and120 Hp. as a tool for statistical analysis. From Table 2 the costs of depreciation, interest, fuel and repair & maintenance gave high values for 120 hp – tractor compared with 85 hp – tractor. This is due to high price of 120 hp –tractor.

Table (2) Comparison of some costs item (SDG/hr) between model output and GIAD Data for two sizes of tractors

Parameters	85-HP tractor		120-HP tractor	
	Model (SDG)	GIAD DATA (SDG)	Model (SDG)	GIAD DATA (SDG)
Depreciation	33750	33750	54000	54000
Interest	41250	39187.5	66000	62700
Fuel	20	21	30	31.5
R&M	3.75	3.70	6	5.9

Purpose of machinery program building:-

The purpose of building machinery management program was the prediction of machinery compliments which includes: machinery technical and economical parameters.

A- ***Machinery technical parameters***: The technical parameters include: effective field capacity (EFC), field efficiency (%), number of implements and power units required to perform agricultural operations, drawbar power, and finally estimates operation cost (SDG)/ fed, giving the user an option to own or to hire machinery to perform the agric. operation. The APAMAS output concerning these parameters will be compared to the applied Giad for Agricultural Services- (Eldamer) machinery system for season 2015- 2016.

B- ***Machinery economical parameters:*** These include machinery cost per feddan and breakeven point (BEP) to aid in machinery ownership or to perform agricultural operation by hiring (custom rate).

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A-Machinery technical parameters: 1. Effective field capacity (EFC):- Technical data of five types of implements namely: chisel plough, the Standard disc plough, disc harrow, leveler and ridger were used by the program. The output data of the program was compared with machinery system of Giad Company for season 2015/2016 and Iowa state university model (table3).

Table (3) The effective field capacity (fed) for five different agricultural operations.

Parameters	GIAD COMPANY	APAMAS	IOWA STATE UNIVERSITY MODEL
CHISELING	3.53	3.54	3.54
DISC PLOUGHING	1.33	1.3	1.3
DISC HARROWING	3.50	3.48	3.48
LEVELING	6.00	6.30	6.30
RIDGING	5.5	5.46`	5.40`

Table (4): The statistical analysis (t-test) of the effective field capacity for APAMAS and Giad company data

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
VAR00001 - VAR00002	.04800	.28718	.12843	-.30858	.40458	.374	4	.728

The results of the output values of effective field capacity (EFC) for five different agricultural operations namely, chiseling , disc ploughing , harrowing, leveling and ridging were shown in table (3). The values of (EFC) calculated by the APAMAS were found to be identical to the Giad company data and the Iowa state university model.

Statistical analysis using t-test table (4), (5) reveals no significant differences between APAMAS, Giad company data and Iowa State university model.

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Table (5) The statistical analysis (t-test) of the effective field capacity for APAMAS and Iowa state university model.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
VAR00001 VAR00002	.00800	.01789	.00800	-.01421	.03021	1.000	4	.374

The input data needed to estimate total cost per feddan and the total costs for all crop operations include:-The purchase prices of agricultural tractors and agricultural machines, the interest rate, taxes, insurance and shelter as percentage of purchase price were used to calculate the annual fixed costs of tractor and agricultural implements. The fuel consumption, oils, labor wage, repair and maintenance costs were needed to estimate the variable costs.

Table (6) showed cost/fed for five agricultural operations estimated by the APAMAS and those collected from GIAD Company. All costs estimated by the APAMAS were found to be higher compared with the costs collected from GIAD Company. Statistical analysis using t-test showed a high significant differences between APAMAS and GIAD Company costs (table 7) .These due to exclusion of some economical items in the calculations done by Giad company for agricultural services .

Table (6) Cost/fed estimated by APAMAS and costs from GIAD Company

Agric. Operation cost (SDG/fed)	APAMAS	GIAD Company Data
Chiselling	310.1	250
Disc ploughing	209.8	160
Disc Harrowing	170.3	130
Field leveling	164.5	120
Ridging	160.1	100

Sensitivity Analysis:-

Sensitivity analysis of the program was run to show the effect of changing cultivated area and machinery purchase prices on APAMAS output. The two input parameters were changed in step of 25% upward from the input values adapted in GIAD Agricultural Company.

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Table (7):The statistical analysis (t-test) of the operations costs for APAMAS and costs from GIAD Company.

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
VAR00001 VAR00002	5.10000E1	8.94427	4.00000	-62.10578	-39.89422	-12.750	4	.000

Program response to change in single input:-

The effect of changing each of the APAMAS input parameters of cultivated area and purchase price of the tractor (85hp) on the outputs of tractor cost/fed , tractor cost/hr, tractor total annual cost were examined for the case of GIAD Company data (season 2015/2016).The purchase price was increased by 25%. Table (8) showed an increase in cost/hr (18.5%), cost/fed (18.5%) and tractor total annual cost (18.4%) **.**

Table (8) Effect of increasing purchase price (25%) on tractor costs.

Tractor cost (SDG)	APAMAS program	25% upward	Change %
Tractor cost per hour	116.5	138.1	18.5
Tractor cost per fed	151.3	179.3	18.5
Tractor total annual cost	116500	138025	18.4

Cultivated area was also increased by 25% . Table (9) indicates an increase in tractor cost /fed (19.8%) and resulted in no change in cost per hour and tractor total annual cost with increase in cultivated area by25%.

Table (9) Effect of changing cultivated area by 25% upward on tractor costs.

Tractor cost (SDG)	**APAMAS program**	**25% upward**	**Change %**
Tractor cost per hour	116.5	116.5	-
Tractor cost per fed	151.3	121.4	19.8
Tractor total annual cost	116500	116500	-

Effect of changing multiple inputs on model output:-

Changing both purchase price of the tractor and cultivated area resulted in change in cost per fed only, (5%) and in no change of cost per hour and total annual cost.

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Table (10) Effect of changing multiple inputs (cultivated area& purchase price) on tractor costs.

Machinery cost (SDG)	AP-Mace program	25% upward	Change %
Tractor cost per hour	116.5	138.1	18.5
Tractor cost per fed	151.3	143.8	5
`Tractor total annual cost	116500	138025	18.4

From table (10) the cost per feddan changed by 5 % and no change in the tractor total annual cost and cost /hr. These results indicate that the increase in cultivated area has an effect on cost/fed.

CONCLUSION

The APAMAS is a user- friendly interactive computer software program which could be run for machinery performance estimation as an aid for machinery managers and agricultural engineers :

1- The APAMAS was successfully validated in comparison to data from Giad Company for agric. services and Iowa state university model. The comparison indicated that there was no significant difference between Giad Company for agric. services data, Iowa State University model and APAMAS program.

2- The APAMAS program calculates the effective field capacity (EFC) for some different tillage implements. The values of EFC calculated by the APAMAS program for five implements were found to be identical to the values of Giad company data and Iowa State University model.

3- The cost/fed for the different five agricultural operations estimated by APAMAS were found to be not identical to Giad company data.

4- Sensitivity analysis by changing either single input of purchase price of machinery and cultivated area, or their combined effects indicate that the APAMAS program is versatile, efficient, valid and can be used as an aid in decision making.

RECOMMENDATIONS

1. The APAMAS program can be used for improvement of farm machinery planning and assist machinery managers in decision making ,and can be used in how to accurately estimate machinery costs for effective and efficient machinery management.

2. The program can be improved in the future by generation of partial budget for machinery operating costs, and it can handle prediction of other machinery .

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