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A Computer Program for Agricultural Machinery Management in Multi -Farm Systems

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ABSTRACT
A computer Model for Agricultural Machinery Management in multi-farm system (APAMM) is a user-friendly interactive program written in a Visual Basic (VB) programming environment for machinery management. It allows the user to interact with it by entering the required inputs and it will carry out the interactive calculations. The APAMM can predict the effective field capacity for different implements (ha/hr), determines the drawbar power needed for each implement (kw), calculates the PTO power for each implement (kw). The program predicts the number of tractors and implements required for each agricultural operation calculates the total operation cost per ha, and per hour and finally estimates total costs of owning and operating machinery for various crop rotations, giving the user an option to hire or purchase the machine. The program enables the user to print out the output which is displayed on the screen. APAMM was successfully verified statistically in comparison to Rahad scheme existing machinery program for two, three and four course rotations. The comparisons indicated that there were no significant differences. Validity and sensitivity tests of the model indicated that the APAMM could be applied to any real-life case successfully and with confidence for any multi- crop farm.
Keywords: Break Even Point; crop rotations; Drawbar power; Machinery management; Verification and Validation; Visual Basic.

Introduction
Agricultural machinery is a major component of agricultural businesses and agricultural development programmes. It offers several improvements to farming system in increasing land and labour productivity, saving time and reduction of risk. Agricultural machinery management is the section of the farm management that deals with the optimization of the equipments phase of agricultural production .it is concerned with the efficient selection, operation, repair and maintenance, and replacement of machinery (Ruiyin *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 times of equipment. 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 estimates play an important role in every machinery management decision (Abdoon, 2010). It is often made to establish hiring rate and to determine the costs of machinery inputs for crop rotation business.

The optimum farm power machinery component is achieved through combination of tractor power required for single operation, the machine size and number of tractors needed to complete field operation at optimum time. Computer programs 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). With the computer becoming available and more appropriate, the complexity of the farm machinery problem had led to numerous efforts to develop models to assist in efficient and effective management of machinery (Grzechowiak, 1999; Ekman, 2002). These developed computer models are user interactive models. Singh and Holtman (1979) developed agricultural field machinery model for multi-crop farms based upon field work specifications, Different crop rotations, various crops in a rotation and using the same implement at the same depth and tractive efficiency make the machinery selection a complicated process.

Great number of tractors makes, wide range of machinery types, availability of different sizes, and various crop rotations make the choice of machinery difficult and complicate machinery management. Introduction of machinery in an agricultural system depends on a wise selection that consider the combination between available tractor power and the required machine size to execute a specific field operation timely. The use of oversized tractors and machines result in higher costs and inadequate machinery sets that may affect the time scheduled for agricultural operations and ultimately reduce crop yield. The determination of tractor fleet size, machinery sets, and available maximum tractor power is necessary to reduce total production cost, manage machinery efficiently and schedule field operations timely (Burbur, 2010).

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 (Burbur, 2010) however, these models that deal with all aspects of machinery management are not in one software program, this study 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 systems.

Materials and Methods

Program Development (Main functions and features): a computer Program for Agricultural Machinery Management in multi-farm system (APAMM) was developed as an interactive user friendly program, where the user is prompt to enter relevant data for the sub-module via a sequence of button driven menus. The user has the option to execute each sub-module separately or the whole

program as one unit. The user has the option of entering his own choice of soil type, crop rotation and crop name 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.

APAMM was developed for multi cropping farms with different types of soils. The computer program consists of machinery programming section and machinery cost section. The computer program main functions are : Compute the effective field capacity (EFC) for different implements (ha/hr) from the user input parameters, determine the drawbar power needed for each implement (kw) , calculate the P.T.O power for each implement (kw), predict the number of tractors and implements required for each agricultural operation from the user input parameters and finally calculate the total operation cost per ha, and per hour and give the user an option to hire or purchase the machine (Figure 1).

Data entry is a step by step process in specifically designed interfaces for each sub-module. Relevant guiding notes are given when necessary to help the user in program usage. In step one, the user is requested to enter input data in tabular format directly from the screen in three enteries: crop rotation, soil type and crop name. The second step is crop operation (tillage, Ridging, planting, harvesting, and other operations). In any operation the user must enter implement and tractor data and then the program will calculate the following parameters:-

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

$$EFC = \frac{SWE}{C}$$

Where: EFC= effective field capacity, S = speed km/h, W: width (m), E:efficiency(%), C: constant (10).

ii. Draw Bar Power kw or (hp):

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

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

iii. $PTO\ power = a + bw + cF$

Where: W = implementing working width, m (ft).F= material feed rate, t/h (ton/h) wet basis. a, b, and c are machine specific parameters.

iv. Number of machine required = $= \frac{operation\ total\ area}{\text{no of hrs x effective field capacity}}$

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

vi. . Operation Total Cost: $OTC = Machine\ Total\ Cost + Tractor\ total\ cost$

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 Rahad schemes (agricultural engineering administration). The Rahad scheme is located on the eastern bank of Rahad River (276 km South East of Khartoum).

The secondary data was collected from bulletins, operation manuals and specifications sheets of machinery and tractors, agricultural operations scheduling programs and internal periodical routine reports. The data given was for the season 2006 -2007. Other secondary data was collected from the most relevant published national and international data and periodicals. The main source data were the ASAE year book (1991), (1993) and Hunt (1993), Agricultural Bank of Sudan Reports

(HQ), and information bulletins from many agricultural machinery dealers in Sudan and worldwide. Descriptive statistical techniques were used to analyze the program results using "SPSS" software mainly T-test and chi-sq.

Results and Discussion

APAMM 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 APAMM output was compared to the applied machinery system of Rahad scheme season 2006- 2007. APAMM succeeded to estimate the total costs of machinery for all agricultural operations (Table 1). From Table 1 the depreciation and interest on investment costs gave high values for 170 hp –tractors compared with 80 hp-tractors. This is due to high prices of 170 hp- tractors. The results are in line with Mirani *et al.*, (1989).

APAMM 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 Rahad scheme. The analysis will take the total cost components of depreciation, repair and maintenance costs, number of fleet size and machine effective field capacity as a tool for statistical analysis.

Satisfaction of 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), number of machines and tractors power required to perform agricultural operations for various crop rotations. The APAMM output concerning these parameters will be compared to the applied Rahad scheme machinery system for season 2006-2007.

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

A-Machinery technical parameters:

1. Effective field capacity (EFC):- Technical data of three types of machines namely, the Standard disc plough, Ridger, and Seed-drill were used by the program. The output data and analysis were shown in table 2 and 3 respectively.

Tables (2 and 3) show that the values of EFC for the different machines predicted by the program were identical to those of Rahad machinery system. Statistical analysis using chi-square reveals no significant differences between APAMM and Rahad machinery system data (Tables 2 and 3).

2. The results of predicting number of power units and machines for the three agricultural operations (tillage, ridging and planting) were shown in table 2 and 3. The number of power units and machinery calculated by APAMM were found identical to the Rahad scheme actual data, number of machinery predicted by the program for discing was found to be lower by 0.1 compared to the Rahad data, this may be due to high effective field capacity reported by APAMM. Statistical analysis using chi-

square (Tables 2 and 3) reveals no significant differences between APAMM output and Rahad machinery data.

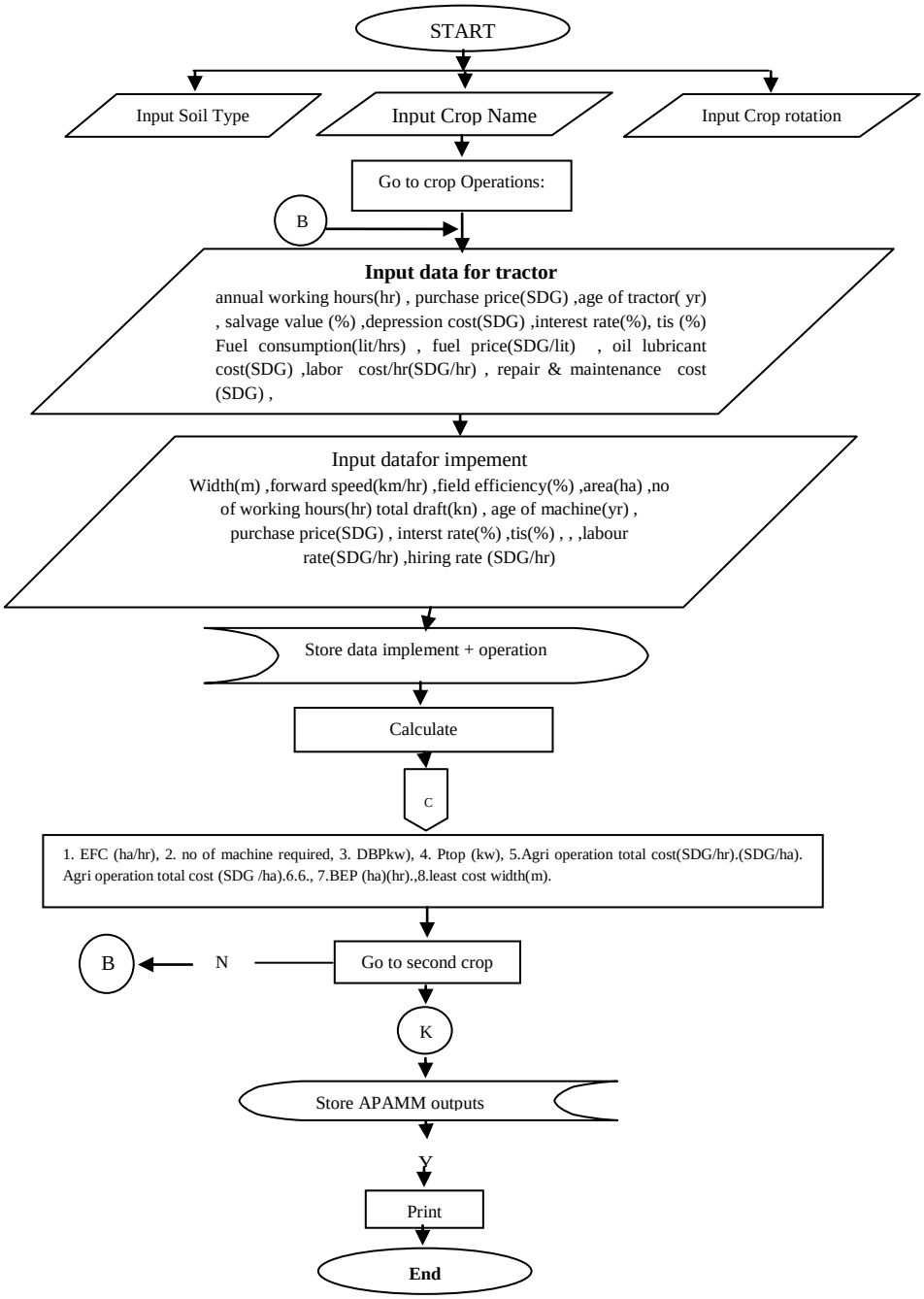

Figure 1: APAMM CP general Flow Chart

Table 1: Comparison of Total costs between APAMM output and Rahad Data for two sizes of tractors

Parameter	170-HP tractor		80-HP tractor	
	APAMM (SDG)	Rahad (SDG)	APAMM(SDG)	Rahad (SDG)
depreciation	20833.3	20833	4500	4500
Interest	37500	37500	8100	8100
Tis	7500	7500	1620	1620
Fuel	3.90	3.9	1.8304	1.8304
Oil	1.46	1.46	.270	.274
R&M	27	27.60	5.40	5.40
Lab	.96	1.2	1.2	.96

Table 2: Comparison of technical parameters between APAMM output and Rahad Data for three types of implements

Output Parameters	Disc plough (w 1.46 m)		Ridger (w 3.2 m with 5 bodies)		Grain drill(w 4.2m)	
	RAHAD	APAMM	RAHAD	APAMM	RAHAD	APAMM
EFC	0.73	0.73	2.1	2.1	1.9	1.91
No of machine	22.9	22.83	40	40	66.3	66.3
Depreciation	20812.5	20833	500	499.99	6600	6599.9
R &M	3750	3750	750	750	4950	4950

Table 3: Statistical description of variation for all observed parameters (Chi Test)

Implement	Observed (O)	Expected (E)	O-E	(O-E)^2	(O-E)^2/E	Chi Clc	Chi Test
Z Disc plough	0.73	0.73	0	0	0	0	*Not Sig*
	22.9	22.83	0.07	0.0049	0.000215	0.00021463	*Not Sig*
	20812.5	20833	20.5	420.25	0.020172	0.02017232	*Not Sig*
	3750	3750	0	0	0	0	*Not Sig*
Ridger	2.1	2.1	0	0	0	0	*Not Sig*
	40	40	0	0	0	0	*Not Sig*
	500	499.99	0.01	1E-04	2E-07	0.0000002	*Not Sig*
	750	750	0	0	0	0	*Not Sig*
Grain drill	1.9	1.91	0.01	0.0001	5.24E-05	0.00005236	*Not Sig*
	66.3	66.3	0	0	0	0	*Not Sig*
	6600	6599.9	0.1	0.01	1.52E-06	0.00000152	*Not Sig*
	4950	4950	0	0	0	0	*Not Sig*

3. Two items of fixed and variable costs predicted by the APAMM were found to be typical to the Rahad machinery cost data for the two types of tractors (Tables 2 and 3). Fixed costs of 170hp- tractors were found to be higher than that of 80hp- tractors and this is due to high purchase prices of 170hp tractors (250.000 SDG/tractor). Variable (operating) costs for the power units predicted by the APAMM were found fairly identical to the actual Rahad data with a little differences in labor costs, and this may be due to the labor annual working hours determined by the APAMM (Tables 2 and 3).

Statistical analysis using chi-square (Table 3) shows insignificant differences between APAMM output and Rahad

scheme machinery data concerning power unit costs.

Conclusions

1- The APAMM is a user-friendly interactive, menu driven program and composed of sub modules with the capabilities for the case of intensive cropping farm.

2- The APAMM offers the opportunity to compare various rotations (different rotations) based on machinery requirements.

3- The APAMM verification and statistical analysis for the case of Rahad scheme reveals the opportunity to more improvement of the machinery system.

4- Validity test of the program in comparison with the Rahad original program of machinery gave a confidence and reliability to use the program for any multi- crop farm and it can be used as a decision – making tool.

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برنامج حاسوبي لإدارة الالات الزراعية لنظام المزارع المتعدده

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المستخلص:

تم إعداد برنامج حاسوبى لادارة الالات الزراعية القائم على بيئة الانظمة الحديثة. وهو برنامج سهل الاستخدام كتب على برنامج Visual Basic (VB) لادارة الالات. يتيح للمستخدم إدخال البيانات المطلوبة لمعالجتها حسابيا كما يمكن المستخدم من إستخراج المستخرجات والتي تظهر علي الشاشة مباشرة . يتنبأ البرنامج (APAMM) بالسعة الحقلية لمختلف الالات الزراعية (هكتار/ساعة) و يحدد القدرة المطلوبة لكل ألة (ك.وات) كقدرة على عمود الجر وقدرة على عمود الادارة الخلفى. كما يتنبا البرنامج بعدد الجرارات والالات المطلوبة لكل عملية زراعية ويقوم بحساب التكلفة الكلية للعمليات الزراعية للهكتار وللساعة ولمختلف الدورات الزراعية (الثنائية والثلاثية والرباعية) إضافة لذلك يتيح البرنامج للمستخدم خيار شراء او إيجار الالة الزراعية . تم التحقق من صحة البرنامج بالتحليل الاحصائى بالمقارنة مع نظام الالات الزراعية بمشروع الرهد واشارت المقارنة انه لا توجد فروق معنوية . أشارت النتائج انِ البرنامج APAMM يمكن تطبيقه على أرض الواقع بكل نجاح وثقه .