A COMPUTER PROGRAM FOR MONITORING CENTRE-PIVOT IRRIGATION SYSTEMS

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ABSTRACT

A computer programme was developed for the purpose of monitoring performance of centre pivot irrigation system. The program was written in "Visual Basic 6.0 Programming Language". It was intended to calculate the main performance parameters of coefficient of uniformity (Cu), distribution coefficient (Du), and Scheduling coefficient (Sc).

For verification of the model, four field trials were carried out during the period December 2007 - July 2008 at four schemes using centre pivot irrigation systems. The schemes were Ras Al Wadi Al Akhdar Project (مشروع رأس الوادى الأخضر), El Bashir Company (شركة البشاير), Tala Company (شركة تالا), and the Arab Company for Agricultural Production and Processing (الشركة العربية للانتاج والتصنيع الزراعى). The schemes were growing alfalfa, except El Bashir Company (شركة البشاير) which was growing onion.

Collected data were fed to the program. The program output was typical to that obtainable through manual calculation and could therefore relief operators from that burden. The program could offer a simple tool for calculating efficiencies for centre pivot.

Key words: centre pivot, uniformity coefficient, distribution uniformity, scheduling coefficient

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1- INTRODUCTION

Irrigation is defined as the artificial application of water to soil for the purpose of crop production. It is generally accepted that irrigation is one of the cultural practices that stabilizes yields and improves productivity in any agricultural development (Teeluck, 1997, Kay, 1983). However, when an irrigation system is also used to apply fertilizers and pesticides, proper management of the system becomes crucial.

The major irrigation method practiced in Sudan is surface irrigation. Use of other systems such as centre-pivot and drip irrigation is now increasing. In comparison to surface irrigation, those systems are more efficient in reducing water losses and demand lower labour (Ali, 2002). There is now little doubt that centre pivot irrigation systems are capable of giving high returns per unit area, but the advantages of the system (lower labour requirement and reduced risk of crop failures) as compared to surface systems are paid for in terms of higher energy requirements and capital costs. Nonetheless, lack of adequate experience may add sault to the injury. When a machine cannot keep up with demand, especially when crop water use is at its peak, the crop does not reach its potential (Barron, 1998). It is therefore of utmost importance to properly select the size of the irrigation system and monitor its performance.

To ease performance monitoring of Centre-Pivot systems in schemes in Sudan, the objective of this work is to offer a simple computing program to help users calculate the following main system parameters:

1. Coefficient of uniformity (Cu).
2. Distribution uniformity (Du)
3. Scheduling coefficient (Su)

2. MATERIALS AND METHODS

2.1 Field data

To develop the program, field data were collected during the period December 2007 to July 2008 from four sites that used centre pivot systems. Three sites were within the Nile Estate in the north of Sudan. Those were Ras Al Wadi Al Akhdar Project, El Bashir Company, Tala

Company, and the Arab Company for Agricultural Production and Processing. The schemes were growing alfalfa, except El Bashir Company. The general texture of the soil in those sites was sandy clay loam. The fourth site was a scheme of heavy clay soil in Khartoum area, used by the Arab Company for Agricultural Production and Processing. Table (1) shows a typical example of collected data and Table (2) shows calculated parameters.

2.2 Measurement of system parameters

Water collection cans were placed at equal distances in a straight line from the pivot point towards the outward direction. The system was allowed to pass over the cans. Water caught in each can was measured using a measuring (graduated) cylinder. To convert readings to depths of water, volume of water caught in each can was divided by the cross sectional area of the top of the can. Performance parameters were calculated as follows:

Coefficient of uniformity (Cu):

This is commonly known as Christiansen coefficient of uniformity. Equation for Cu as stated by Christiansen (1942) is:

$$Cu = 100.\left[1 - \frac{\sum x}{mn}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

Cu = Coefficient of uniformity (%).

x = deviation of individual observation from the mean (mm).

n = number of observations.

m = mean value of observation (mm).

Distribution uniformity (Du)

The uniformity of water application could be computed by dividing the lowest values caught in quarter of the cans (low quartet) by the average depth caught in all cans (Ali, 2002).

$$Du\% = \frac{\text{mean low quarter caught in the cans}}{\text{average depth caught in all the cans}} \quad \dots\dots\dots (2)$$

Scheduling coefficient (Sc %)

Scheduling coefficient determines the critical area in the water applicant pattern. This is the area receiving the least amount of water, which is divided by the average amount of water applied through the irrigation area (Solomon, 1988).

Sc was calculated from:

$$Sc\% = \frac{1}{Du} * 100 \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \quad (3)$$

Where:

Sc = scheduling coefficient.

Du = uniformity of distribution (decimal)

3. RESULT AND DISCUSSION:

Development of the program

The program was primarily written to calculate Cu, Du and Sc as defined by equations (1), (2) and (3) respectively. Data collected from each of the four sites were entered in a spread sheet provided by the program to verify validity. Flow charts (1) to (4) show how the program calculates the parameters and Fig 1 shows the result of a typical run.

Table 1 shows data collected at Arab Company. Data from the other sites was collected and tabulated in a similar manner. Calculated values for uniformity coefficient, uniformity of distribution, and scheduling coefficient for the four sites are shown in Table (2)

a) Uniformity coefficient

The uniformity coefficient for the systems of the study was found to be 84% in Tala 79% in El Bashair Project and Arab company, and 78% in

Ras El Wadi Al AkadarProject. Except for Tala (تالا) Project, those results were lower than a range of 81 to 96% obtained by Duke (1992), and that of 81 to 90% obtained by Saeed (2001) for a centre pivot system under variable wind speed. However, according to Michael (1978), a satisfactory uniformity coefficient should be 85% or more. Therefore, only the system in Tala was marginally acceptable (according to the 85% level).

b) Uniformity of distribution

The uniformity of distribution was found to be 79% in El Bashair(and Tala project, 71% in Arab company, 69% in Ras El Wadi Project. Solomon (1988), Keller and Bliensner (1990) and Jorge, Pereira, (2002) and Rain Baird (2008) found that the uniformity of distribution ranged from 75 to 85%. Ali (2002) and El Badawi (2001) found uniformity of distribution of about 77%. Therefore, uniformity of distribution was around the lower limits of the reported range in El Bashir and Tala projects, and below the range in the Arab Company and Ras El Wadi Project.

c) Scheduling coefficient

The scheduling coefficient (SC) was found to be 1.40, 1.41, 1.42, and 1.43 in Tala, Arab company, Al Bashair , and Ras Al Wadi, respectively.

SC was used because it depends on Du determination. Connellan (2002) and Abdelrahaman (2006), mentioned that an efficient irrigation system should aim to achieve an SC of less than 1.3. Values obtained at the four projects were above this limit.

Conclusion:

The program successfully calculated the performance parameters of centre pivot systems used in the sites of the study. Based on calculated values, system operators could make necessary adjustments to achieve acceptable performance.

Table1. Depth of water caught in the cans (mm) in Arab Company for Agricultural Production and Processing

Distance from pivot (m)	Run 1	Run 2	Run 3	Distance from pivot (m)	Run 1	Run 2	Run 3
10	22.1	12.36	17.69	210	22.10	20.84	25.45
20	13.57	22.30	27.87	220	29.08	29.08	16.00
30	17.94	14.78	16.97	230	19.63	16.97	27.39
40	17.45	15.27	14.54	240	28.11	19.39	17.94
50	24.24	17.21	12.85	250	29.81	18.42	19.63
60	21.33	11.88	20.12	260	24.96	15.75	24.96
70	16.72	12.60	13.81	270	28.84	24.96	17.21
80	20.12	10.91	16.00	280	32.23	18.18	20.12
90	22.10	17.94	15.51	290	17.45	10.91	15.03
100	20.36	13.81	17.45	300	34.66	26.42	22.78
110	13.33	12.85	16.24	310	23.99	26.42	18.42
120	26.42	14.06	15.27	320	11.63	34.90	17.69
130	25.93	17.45	15.03	330	13.33	24.24	14.78
140	19.63	19.63	17.45	340	23.02	15.03	28.84
150	23.99	16.97	16.00	350	13.81	17.94	21.33
160	20.60	24.48	21.81	360	19.39	19.63	18.90
170	16.24	21.81	14.54	370	17.45	18.90	14.54
180	14.30	16.00	10.66	380	27.14	14.54	22.78
190	20.84	20.84	20.12	390	19.39	22.78	19.63
200	16.97	22.06	17.94	400	21.81	13.33	19.39

Table2. Performance coefficients for Centre Pivot Systems

Company	Coefficient of Uniformity (%)	Distribution Uniformity (%)	Scheduling Coefficient
Arab Company for Agricultural Production	79	71	1.41
El Bashir Jordanian Company	78	79	1.42
Tala Company	86	79	1.40
Ras Al Wadi Alakhdar Project	77	69	1.43

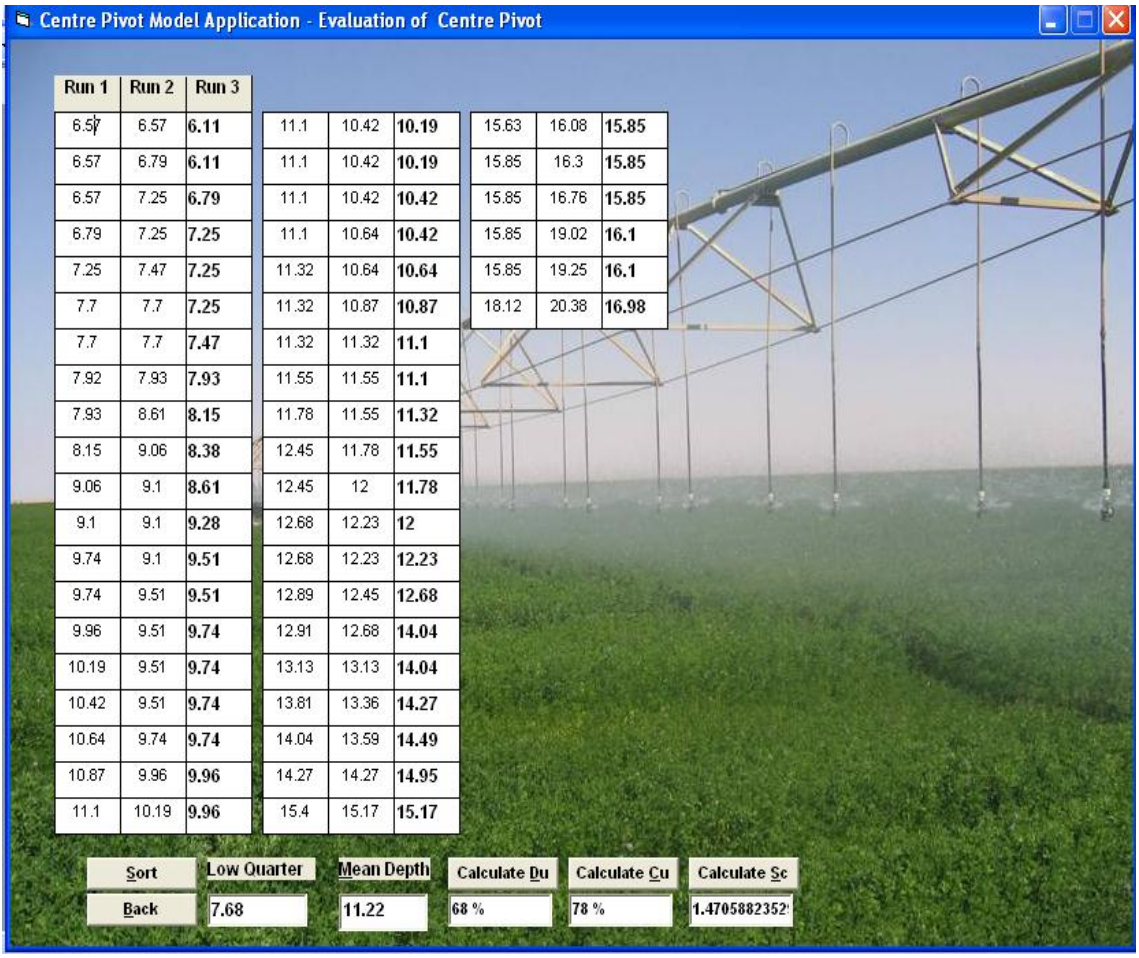

Fig. 1 Evaluation of centre pivot parameter.

Program Flow Charts

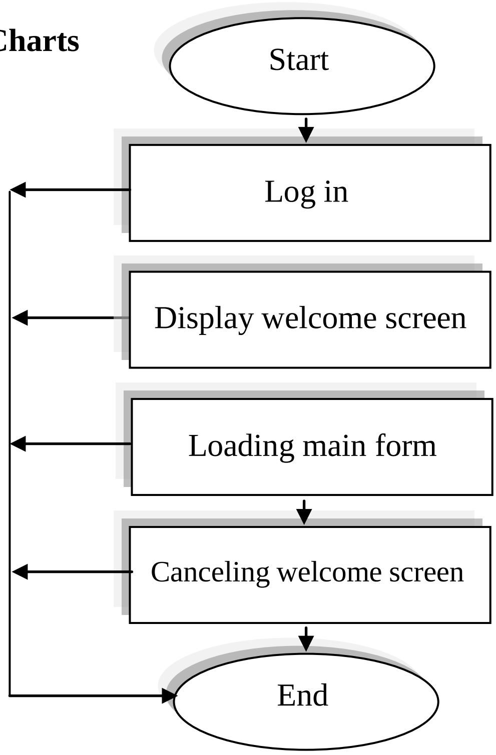

Fig 1. Welcome screen flow chart

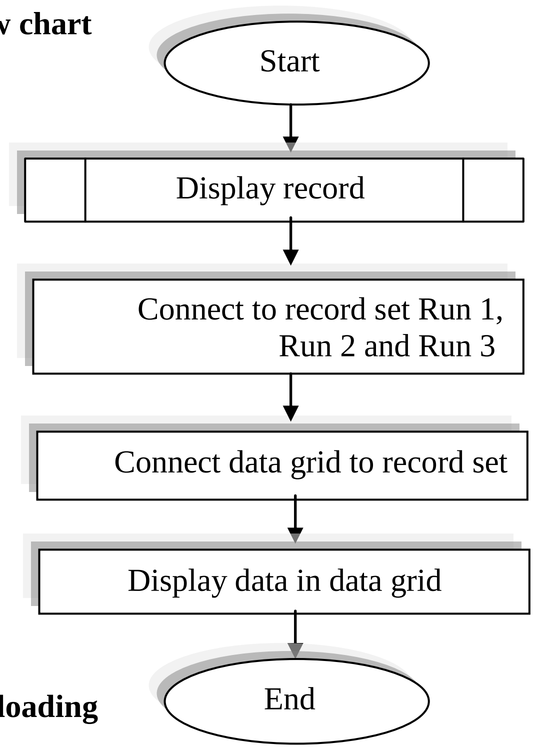

Fig 2. Flow chart for data loading

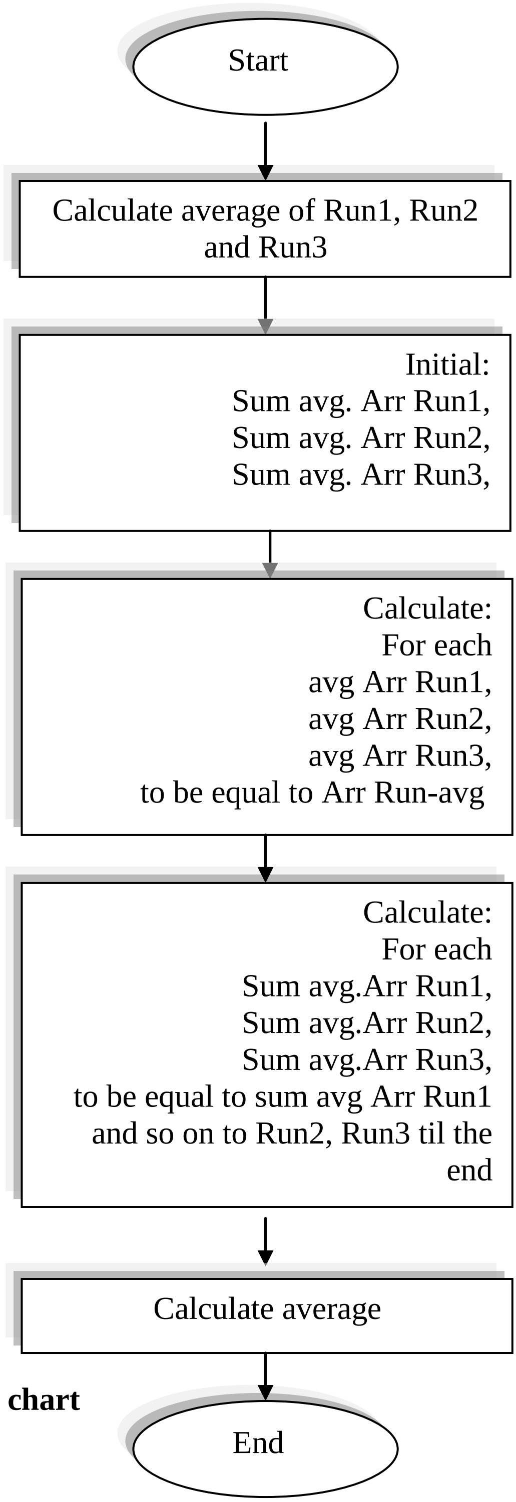

Fig 3. Evaluation flow chart

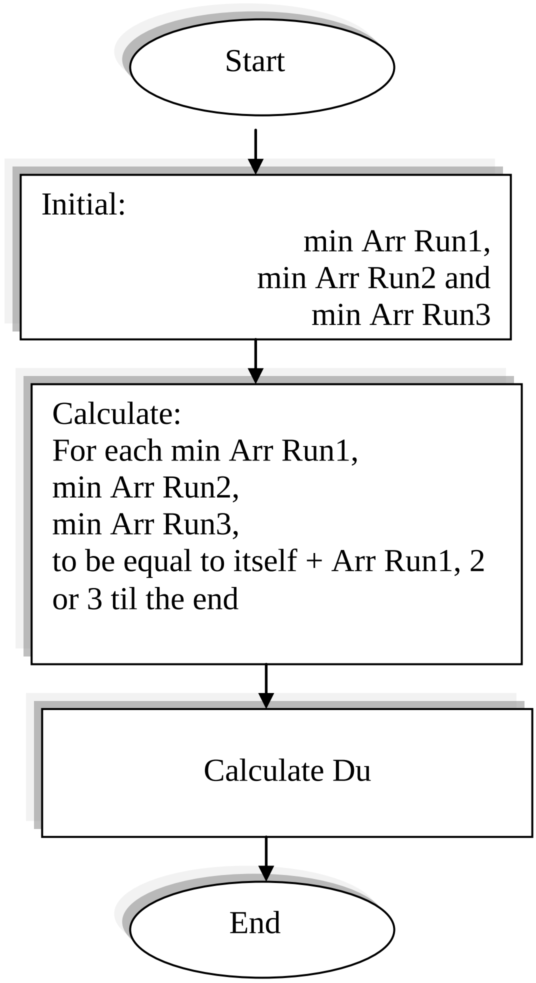

Fig4. Flow chart for calculating distribution uniformity (Du)

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المخلص العربى

منهاج حاسوبى لتقييم أنظمة الرى المحورى

أسامه عثمان على[١] ، عبد المنعم الأمين محمد[٢] ، البشير على حماد[٣] و محمد عبد الله محمد[٤]

تم تطوير انموذج حاسوبى بغرض تقييم نظام الرى بالرش المحورى، وتمت كتابة الانموذج باستخدام لغة البرمجة "فيجول بسيك ٦.٠" . هذا الانموذج يقوم بتقييم أداء النظام عندما تتم تغذيتة بالبيانات المطلوبة. النظام يقوم بحساب معاملات الأداء الأساسية وهى معامل انتظام النظام Du، وانتظام التوزيع Cu ومعامل الجدولة Sc.

لإثبات صحة الأنموذج أجريت تجارب حقلية خلال الفترة من ديسمبر ٢٠٠٧ الى يوليو ٢٠٠٨ فى أربعة مشاريع بولاية نهر النيل تستخدم نظام الرى بالرش المحورى وهى مشروع رأس الوادى الأاخضر شمال عطبرة وشركة البشائر الاردنية جنوب الدامر وشركة تالا شمال شندى والشركة العربية للانتاج والتصنيع الزراعي فى منطقة الخرطوم. مخرجات البرنامج كانت مطابقة للتي تمت يدويا. البرنامج يوفر أداءا بسيطا لحساب كفاءات نظام الري بالرش المحوري.

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