U. of K. J. Agric. Sci. 17(2), 228-236, 2009

Performance of Counter-Poise 'Shadouf' in Zalengi Area, West Darfur State, Sudan*

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Abstract: This study was carried out to determine the performance of the counter-poise 'Shadouf', which is widely used along Wadi Azum in Zalengi area, West Darfur State, Sudan, to irrigate small holdings. The study included data collection on 'Shadouf', crop water requirements and soil characteristics; namely, mechanical analysis and hydraulic conductivity. The results showed that the 'Shadouf' has an average discharge rate of 1.34 ℓ/s, enough to irrigate an area of 0.22 feddan (1 fed. = 0.42 ha) during winter or 0.18 feddan during summer when the device is operated for six hours per week.

Key words: Counter-poise; irrigation; Zalengi; Sudan

INTRODUCTION

From early times, farmers in Sudan used various traditional methods, such as the Persian water wheel 'Sagia' and the counter-poise 'Shadouf', to lift water for irrigation purposes from the Blue Nile, White Nile and River Nile and from ground aquifers in Kordofan, Kassala and Darfur states. Nowadays, the use of 'Shadouf' in Darfur states, particularly along Wadi Aribu and Wadi Azum, is widespread. This is due to the high initial and operation costs of irrigation pumps. Other reasons that encourage the use of 'Shadouf' include the favourable characteristics of the alluvium aquifers, the shallow depth of the ground water and its annual recharge by direct rainfall, seasonal small streams and surface runoff.

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The counter-poise bucket lift (Plate 1) consists of a long wooden pole, which is pivoted as a lever on a post. A weight, usually a large stone, ball of dried mud or a basket full of stones, is fixed to the shorter end of the pivot. To operate the lift, a person pulls down the rope or rod (which is firmly attached to the long pole), using his body weight and strength until the bucket is immersed in the water and filled. The bucket is lifted up by the counter weight. It is capable of lifting water up to 4 metres (Michael 1978; ITDG 2004).

Plate 1. The indigenous 'Shadouf' in Zalengi, Sudan

Ghosal *et al.* (1992) conducted a field experiment to evaluate the performance of a counter-poise bucket in terms of discharge and human fatigue factors for three types of water lifting buckets; namely, empty kerosene tin (15 litres capacity), earthen pot (10 litres capacity) and metal bucket (13 litres capacity). The kerosene tin gave a maximum discharge of 3.08, 2.93, 2.61 and 2.31 ℓ/s, at the lift heads of 1.28, 1.6, 2.2 and 2.5 m, respectively. The operator got tired after an hour of operation. Nema and Rao (1987) found that the discharge of a swing basket, dhone, counter-poise and chain pump were 2.02, 1.94 and 3.1 ℓ/s, respectively, at an average head of 1.5 m. Human muscle power can handle quite a large load (over loads) for short periods of time, but the power capability diminishes if more than few minutes of activity are required. The power capacity is also a function of built, age, state of health and weight of individual (Frankel 1986).

The principle of counter-poise operation is the same as that of the bar balance; it is adjusted to balance the weight of a full container. As reported by Michael (1978), the proper weight of the counter-poise can be computed as follows:

$$W_1 D_1 = W_2 D_2$$

where:

W_1, and W_2 = the weight at the end of the pole (counter-poise) and the weight of the full container of water at ground level, respectively.

D_1 and D_2 = the distance from the fulcrum to the counter-weight and the container, respectively.

The power needed (from the operator) to pull the empty container down to the depth of the under ground water depends on (1) the distance from the ground level to the ground water (2) the weight of the empty container and (3) the distance D_2. The full or partly full container is raised to ground level by the counter weight (W_1) at the end of the long wooden pole.

This study was undertaken at Zalengi town to appraise the performance of 'Shadouf'. The specific objectives were (i) to determine the discharge of 'Shadouf' as affected by age of operator, operation time, lifting head and type and capacity of lifting bucket and (ii) to estimate the area that can be irrigated by the device.

MATERIALS AND METHODS

The study was conducted in areas along Wadi Azum near Zalengi town, West Darfur State (latitudes 12°49′N, longitude 23°29′E and altitude 900 m above mean sea level) during the winter and summer seasons of 1994/95 and 1995/96.

Twenty-five farmers (each with his own 'Shadouf') were surveyed. They were randomly chosen in terms of sex (male or female) and state of health for determination of discharge as a function of age and length of operation time. The twenty-five farmers were divided into five groups according to their age (10-15, 16-20, 21-30, 31-40 and 41-60 years). The treatments were compared in a randomized complete block design. Each treatment was replicated five times, each replicate represented a length of time (1, 5, 10, 15 and 20 minutes).

Fifteen farmers were also randomly chosen to determine the 'Shadouf' discharge as affected by depth to water level. The farmers were divided into three groups according to the well depths (1.0-1.5, 1.6-2.0 and 2.1-3.0). The average discharge was taken and tabulated.
The crop water requirements were estimated using the modified Penman equation as outlined by Doorenbos and Pruitt (1977) based on data from Zalengi Meteorological Station.

Soil samples were collected from three different locations along Wadi Azum to a depth of 40 cm. Soil texture was determined using the hydrometer method as described by Day (1956). USDA textural classification chart was used to specify soil class.

RESULTS AND DISCUSSION

Table 1 shows the discharge from 'Shadouf' as affected by the length of operation time and age of operator. The discharge decreased as pumping was continued because of operators fatigue. Fatigue was observed five minutes from the start of pumping, after which a significant ($P \leq 0.05$) decrease in water discharge was recorded. As pumping continued up to a certain point of time (break-point), the operator takes a rest before the operation is resumed. At the end of the day, the net working hours will be six to seven. The results agree with those reported by Frankel (1986) who stated that human power diminishes after a few minutes of activity.

'Shadouf' discharge showed significant ($P \leq 0.05$) difference in the discharge rate between different age groups, except between age groups of 31-40 and 41-60 years where no significant differences were obtained. This may be because the last age group (40-60 years) was more experienced in dealing with 'Shadouf'.

The mean discharge by the 'Shadouf' was 1.34 ℓ/s (Table 1), which is less than the discharge rate of 2.34 ℓ/s reported from India by Nema and Rao (1987). This may be because of the difference in the physical strength and health of the operators, and the fact that 'Shadouf' in Zalengi area is operated by children, women and old men.

'Shadouf' discharge decreased as the lifting head increased and consequently the time required to lift the bucket increased, which ultimately affected the discharge. The average discharge was 88.0, 84.0 and 77.8 ℓ/min from depths of 1.0-1.5, 1.6-2.0 and 2.1-3.0 m, respectively.

The lifting buckets used in Zalengi area were empty kerosene containers (8.18 litre capacity), tin buckets (5.49 litre capacity) and wooden buckets (6.75 litre capacity). The tin buckets were more commonly used than the other types, because they are light and available.

Table 1. Discharge of 'Shadouf' as a function of age of operator and Length of operation time

Age of Operator (yrs)	Discharge rate (ℓ/min)					Mean	
	1 min	5 min	10 min	15 min	20 min	ℓ/min	ℓ/sec
10 – 15	77.5	73.1	72.6	72.2	71.4	75.6	1.2
16 – 20	81.3	81.2	80.2	77.7	76.2	79.4	1.32
21 – 30	88.4	88.0	87.0	83.3	81.9	85.7	1.42
31 – 40	85.2	82.1	81.8	80.7	80.0	81.3	1.36[a]
41 – 60	81.8	81.7	81.4	80.9	80.4	81.2	1.35[a]
Mean/min	81.4[a]	81.3	80.6	78.7	77.8	80.6	80.07
Mean/sec	1.4	1.36	1.34	1.32	1.29	1.34	1.34

Crop water requirement (CWR)

The CWR values for 1994/95 and 1995/96 seasons showed minor variations (Table 2) due to weather conditions. According to the calculated CWR for the experimental area, 'Shadouf' can irrigate 0.22 feddan (1 fed. = 0.42 ha) during the winter season and 0.18 feddan during the summer season when it was operated for 6 hours a week.

Soil mechanical analysis

Soil mechanical analysis showed that the textural class of the topsoil (0-40 cm) in Wadi Azum was loamy sand, consisting of 82% sand, 12% clay and 6% silt. The average hydraulic conductivity of the topsoil was 0.053 cm/min.

CONCLUSION

The results of the present study indicated that the efficiency of 'Shadouf' in Zalengi area is low; therefore, further work is needed to develop the device to deliver more water so as to bring more land under irrigation

Table 2. Crop water requirements (CWR) in 1994/95 and 1995/96 at Zalengi, Sudan, as calculated by the modified Penman equation

Season	Month	CWR (mm)	
		1994/95	1995/96
Winter	November	177	141
	December	118	120
	January	127	124
	February	133	136
	Total	495	522
Summer	March	164	164
	April	177	171
	May	177	161
	June	105	120
	Total	623	616

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مجلة جامعة الخرطوم للعلوم الزراعية: المجلد السابع عشر-العدد الثاني، 2009م

أداء الشادوف في منطقة زالنجى بولاية غرب دار فور

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موجز البحث: اجريت هذه الدراسه لتحديد خصائص الشادوف الذى يكثر استخدامه على ضفاف وادي أزوم في منطقة زالنجى بولاية غرب دارفور لري الحيازات الصغيرة. اشتملت الدراسة على جمع معلومات عن الشادوف المستخدم في المنطقة لتحديد بعض الخواص ذات الصلة بكفاءة رفع المياه الجوفية الضحلة ومقارنة ذلك بالاحتياجات المائية للمحاصيل، إضافة إلى دراسة صفات التربة (التحليل الميكانيكى). أوضحت نتائج الدراسة أن الشادوف المستخدم في المنطقة يرفع 1.34 لتراً فى الثانية مما يمكن من ري مساحة قدرها 0.22 فدان في الشتاء و0.18 فداناً في الصيف إذا عمل لمدة 6 ساعات في الاسبوع.

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