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# Performance of Basin and Bubbler Irrigation Systems under River Nile State Conditions[*]

Yassir Mohamed Ibrahim[1], Amir Bakheit Saeed and Ali Widaa M. Elamin

**Department of Agricultural Engineering, Faculty of Agriculture, University of Khartoum, Shambat, Sudan**

**Abstract:** This study was conducted in the Jordanian Bashair project, River Nile State, during two seasons (2007 and 2008) to evaluate the performance of irrigation systems applying different amounts of irrigation water. The treatments were surface irrigation method (basin irrigation system) and localized irrigation system with two types of distributors: locally made bubblers and imported bubblers. The irrigation water amounts were given as percentages (50%, 75% and 100%) of date palm watering requirement (ETc). ETc was obtained from the means of the previous thirty years, using CROPWAT4 WINDOWS. The performance of the irrigation system was evaluated with reference to the application and storage efficiencies and distribution uniformity. The experiment was organized in a split plot design with three replicates. The irrigation systems showed negative effect on distribution uniformity and positive effect on application and storage efficiencies. The locally made and imported bubblers revealed highly significant ($P \leq 0.01$) differences with application and storage efficiencies, while there was no significant difference between them. The 50% ETc recorded high significant values of application efficiency, but less values of storage efficiency and distribution uniformity. Interaction of the irrigation systems and amounts of water showed positive effect, whereas locally made bubblers showed higher values of application and storage efficiencies with 50% and 100% ETc, respectively. On the other hand, the basin irrigation system gave highest values of distribution uniformity with 75% and 100% ETc .Hence, it was concluded that using bubbler irrigation system would give high irrigation efficiency, thus saving water for other agricultural activities.

**Key words:** Irrigation systems; efficiencies; date palm

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[*]Part of a Ph.D. thesis by the first author, the University of Khartoum, Sudan

[1]Department of Agricultural Engineering, Faculty of Agriculture, University of Wadi Elneel, Dar Mali, Sudan

## INTRODUCTION

With increasing demand on water resources, irrigation efficiency is becoming more important to manage these resources effectively (Israelsen *et al*. 1978). Irrigation efficiency can be defined in many different ways depending on the perspective that is considered. In fact, there are over 30 different definitions in use.

As the demand for water increases, there will be increasing competition for this limited resource. Water management will become an essential practice to be adopted by farmers, and can be improved by raising the overall irrigation efficiencies. The concept of the efficiency is to show where improvements can be made. When evaluating the performance of a farm irrigation system, it is often useful to examine the efficiency of each system component, which identifies the defect in each component (Yan *et al*. 2000).

Irrigation efficiency is a basic engineering term used in irrigation science to characterize irrigation performance, evaluate irrigation water use and promotes better or improved use of water resources. The overall irrigation efficiency covers many concepts such as diversion, conveyance, application, storage, consumptive use and distribution uniformity efficiencies. Application efficiency is the ratio of the water stored in the root zone to the applied irrigation water (ASCE 1978). It can vary considerably depending on irrigation management and type of system. Application efficiency for flood-irrigated orchards is high (89%) compared with typical flood irrigation for other crops (73%), (Zalidis *et al*. 1997). Keller and Bliesner (2000) reported that pressurized irrigation systems if adequately designed and managed can give irrigation efficiencies greater than 80%. The distribution uniformity represents the spatial evenness of the applied water across a field or a farm as well as within a field or farm. On the other hand, distribution uniformity is higher with micro irrigation than with surface irrigation (Al Mojahed 2006).

This study was conducted to evaluate the performance of three irrigation systems while applying different amounts of date palm watering requirement.

## MATRIALS AND METHODS

The experimental work was carried out at the Jordanian Bashair project which is located at 15 kilometres south of Eldamar town, River Nile State, Sudan (longitude $33^0 50^' E$, latitude $17^0 20^' N$ and altitude 364 m above M.S.L.) in an area of 1.7 ha during two consecutive seasons (2007 and 2008). The region is classified as semi-arid with great variation in temperature and rainfall. The weather is very hot in the summer and cold in winter with annual average maximum temperature $37^0C$ and minimum temperature $21.8^0C$. The soil of the experimental site is sandy clay loam with high percentage of sand.

The experiment was arranged in a split plot design with three replicates. The irrigation systems were assigned to the main plots and the irrigation water amounts to the subplots. Three irrigation systems (basin, locally made bubblers and imported bubblers), each with three different amounts of irrigation water {50% 75% and 100% of date palm watering requirement (ETc)}. The amount of irrigation water was measured using a cumulative flow metre. The frequency of irrigation was four days, while the amounts of water applied were 460.70, 462.58 and 683.63 mm/ year by imported bubbler, locally made bubbler and basin irrigation systems, respectively. The size of each basin was 4.2 $m^2$, while the spacing between bubblers was 8 m and 10 m between laterals.
The bubblers rates of discharge were calibrated volumetrically at three different positions along the lateral (12, 24, and 48 m starting from the submain ).

The application and the storage efficiencies and the uniformity distribution were determined from the depth of water which was applied to the field and that stored in the soil. This was done by subtracting the water depth before and after irrigation at three points in each lateral, then the averages of soil water depths were recorded .This procedure was also adopted in the basin irrigation. The water depths were calculated by the following equation as suggested by Aamer (2002):

D= (Ma – Mb)*Bd*Sd*P

where

D = storage depth (cm).
Ma =soil moisture content after irrigation (decimal).
Mb = soil moisture content before irrigation (decimal).
Bd = bulk density ($g/cm^3$)
Sd = soil depth (metres)
P = wetted soil (decimal).

Application efficiency was calculated as

Ea = 100(Vs/ Vf)

where

Ea is the application efficiency (%), Vs is the amount of irrigation water needed by the crop ($m^3$), and Vf is the volume of water delivered to the field ($m^3$) (Israelsen *et al*. 1978).

The storage efficiency was given as

Es = 100(Vs/ Vrz)

where

Es is the storage efficiency (%) and Vrz is the root zone storage capacity ($m^3$) Israelsen *et al*. (1978).

The Distribution Uniformity (DU) was measured using the equation stated by Christiansen (1946).

DU = 100 (1-[LQ/M])

where

DU = distribution uniformity (%)
LQ = average of the lowest one quarter of the total irrigation depths
M = average of the total irrigation depths

## RESULTS AND DISCUSSION

Table 1 shows that irrigation systems had highly significant (P≤0.01) effects on the application and storage efficiencies, while, there was no significant effect on the uniformity distribution. The mean values revealed that the imported and locally made bubblers gave the highest application and storage efficiencies, whereas the basin irrigation system ranked last. The higher application and storage efficiencies of the bubblers irrigation systems may be attributed to the reduced rates of evaporation, run off and deep percolation loss as compared with the basin irrigation system. In the basin irrigation system, particularly in heavy clay soils, the irrigation water is ponded on the soil surface, thus more subjected to loss by evaporation, deep percolation and leakage due to frequent physical destruction of the dykes. These results are in consistence with those reported by Goyal et *al*. (1985).

Table 1. Effect of irrigation systems on efficiencies of these irrigation systems

| Irrigation system | Irrigation efficiency | | |
|---|---|---|---|
| | Application efficiency (%) | Storage efficiency (%) | Distribution uniformity (%) |
| Imported bubblers | 88[a] | 61[a] | 98[a] |
| Locally made bubblers | 88[a] | 61[a] | 97[a] |
| Basin | 71[b] | 44[b] | 97[a] |
| LSD (0.01) | 4.56 | 12.3 | 2.99 |

Means with the same letter within the same column are not significantly different at 1% level of probability.

Table 2 shows that watering amounts had a highly significant (P≤0.01) effect on the three aforementioned efficiencies. The 50% ETc recorded the highest application efficiency followed by 75% ETc, while 100% ETc gave the lowest application efficiency. These results are in agreement with those reported by Al Mojahed (2006).

The 75% ETc and 100% ETc had the highest ranking of the means of storage efficiency and uniformity distribution, whereas 50% ETc ranked last. The general trend is that storage efficiency and uniformity distribution are increased with increasing watering amounts. This is in accord with the results obtained by Al Mojahed (2006).

Table 2. Effect of applied amount of water on irrigation efficiencies

| Watering amounts (% of ETC) | Irrigation efficiency | | |
|---|---|---|---|
| | Application efficiency (%) | Storage efficiency (%) | Distribution uniformity (%) |
| 100 | 76[c] | 67[a] | 97[ab] |
| 75 | 84[b] | 62[a] | 98[a] |
| 50 | 91[a] | 48[b] | 95[b] |
| LSD (0.01) | 2.90 | 11.75 | 2.90 |

ETc =crop water requirement

Means with the same letter within the same column are not significantly different at 1% level of probability.

The interaction of irrigation system and watering amounts had clear effect on the efficiencies (Figs. 1, 2 and 3). Locally made bubblers with 50% ETc combination recorded the maximum application efficiency, while the basin irrigation system with 100% ETc combination recorded the lowest value. On the other hand, locally made bubblers with 100% ETc recorded the highest value of storage efficiency, while the lowest values were registered by the basin system with 50% ETc combination. The basin irrigation system with both 75% and 100% ETc showed the highest values of distribution uniformity. Application efficiency with most irrigation systems decreased with increasing watering amounts in contrast to the storage efficiency which was increased with increase of watering amounts. This may be due to the fact that the depth of water stored in the root zone during irrigation varied according to the different irrigation systems and watering amounts. Moreover, the water applied by the bubblers under the highest rate of watering amounts eliminated water losses through deep percolation and evaporation as compared with basin irrigation under the same situation. In drip irrigation, it is possible to control the water amount by proper management and reduce water losses by 50% (Zeng *et al.* 2009).

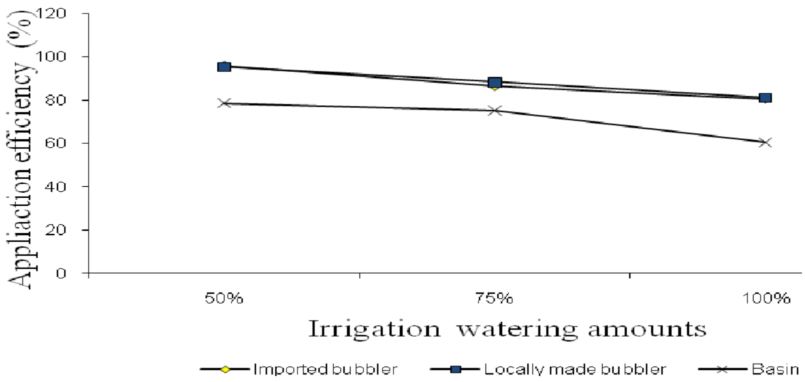


Fig. 1. Effect of three irrigation systems and watering amounts on the application efficiency

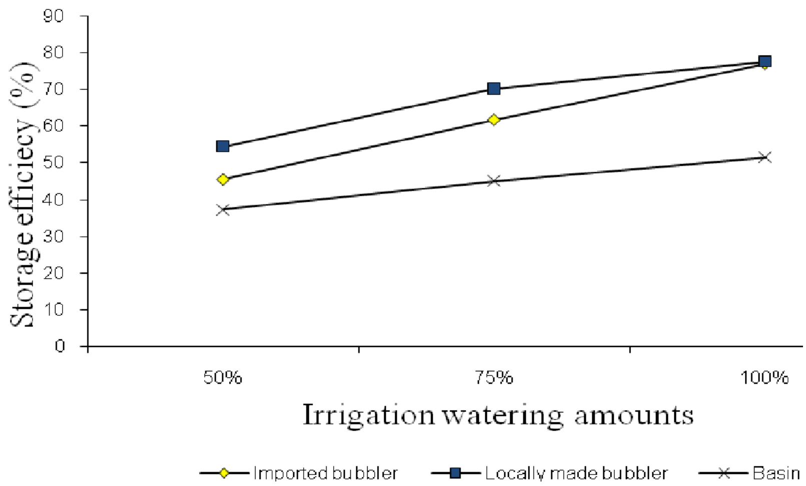


Fig. 2. Effect of three irrigation systems and watering amounts on the storage efficiency

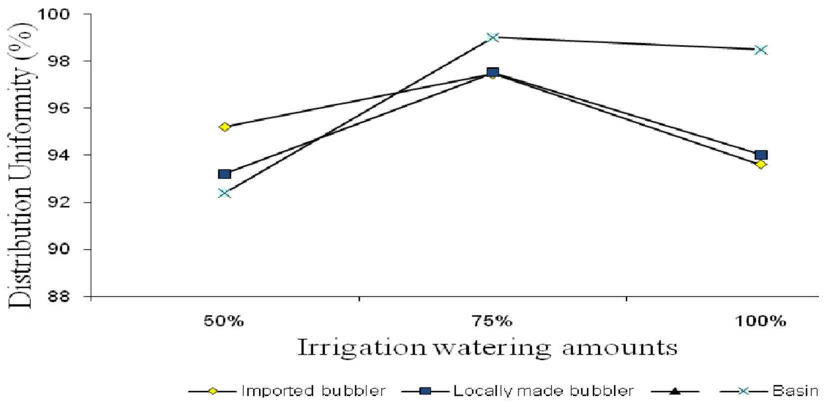


Fig. 3. Effect of three irrigation systems and watering amounts on the distribution uniformity

## Conclusion

i. Higher irrigation efficiencies can be obtained by proper selection of the irrigation system.
ii. In order to achieve high field irrigation system by bubblers, the right bubbler with the least coefficient of variation must be selected.
iii. Using bubblers systems to irrigate date palm, instead of basin irrigation system, minimizes water used and increases irrigation efficiency.
iv. Amounts of irrigation water have positive effect on irrigation efficiencies

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# أداء أنظمة الري الحوضي و الفقاعي تحت ظروف ولاية نهر النيل*

ياسر محمد إبراهيم[1] و أمير بخيت سعيد و علي وداعة محمد الأمين

**قسم الهندسة الزراعية- كلية الزراعة- جامعة الخرطوم، شمبات- السودان.**

**المستخلص:** أجريت هذه الدراسة بولاية نهر النيل (مشروع بشائر الأردني) خلال موسمي 2007 و 2008 لتقييم أداء نظم الري مع كميات ماء مختلفة. كانت المعاملات كالاتي: طريقة الري السطحي (نظام الري الحوضي) والري الفقاعي بنوعين من الموزعات هما الفقاعي المصنع محليا والفقاعي المستورد . أعطيت كميات مياه الري كنسب مئوية (50% و 75% و100%) من المتطلبات المائية لنخيل البلح (ETc) والتي تم الحصول عليها من متوسطات للثلاثين سنه الماضية باستخدام برنامج الحاسوب CROPWAT4 WINDOWS. قيم أداء نظام الرى بإستخدام كفاءات الإضافة والتخزين بالإضافة لأنتظامية التوزيع. نفذت التجربة بتصميم القطع المنشطرة بثلاثة مكررات. أظهرت أنظمة الري تأثيراً سلبياً علي إنتظامية التوزيع وتأثيراً إيجابياً علي كفاءات الأضافة و التخزين. أظهر الفقاعي المصنع محليا والفقاعي المستورد فروقاً معنوية ($P\leq0.01$) مع كفاءات الأضافة و التخزين، بينما لم تكن هنالك فروقاً معنوية بينهما. سجل كل ال 50% من بخرنتح المحصول أعلى قيم معنوية لكفاءة الإضافة و أقل كفاءة تخزين وإنتظامية توزيع. كما سجل التفاعل بين إنظمة الري وكميات المياه تأثيراً إيجابياً بينهما، وأظهر الفقاعي المصنع محليا أعلى قيم لكفاءات الإضافة و التخزين مع 50% و 100% من بخرنتح المحصول علي التوالي. من جهة أخري، أعطي نظام الري الحوضي أعلى إنتظامية توزيع مع 75% و 100% من بخرنتح المحصول. دلت هذه النتائج علي أن إستخدام الري الفقاعي يعطي أعلي كفاءة ري مما يؤدي لتوفير المياه لأنشطة زراعية أخري.

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* جزء من إطروحة دكتوراه للكاتب الأول، جامعة الخرطوم، السودان

[1] قسم الهندسة الزراعية، كلية الزراعة، جامعة وادي النيل، دارمالي، السودان