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Effect of a Semi Portable Solid Set Sprinkler System on Growth and Yield Attributes of Maize (*Zea mays* L.)*

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Abstract: A field experiment was carried out during seasons 2007 and 2008 at Elailafoon area 30 km south east of Khartoum on the eastern bank of the Blue Nile. The objective was to study the effect of sprinkler irrigation system as compared to the surface irrigation system on growth and yield attributes of forage maize. The treatments consisted of a semi portable solid set sprinkler and basin irrigation systems with two maize cultivars (Mugtama 45 and Baladi). The treatments were arranged in a nested design and replicated three times. The soil physical and chemical properties of the experimental site were analyzed. Data on plant height, number of leaves per plant, stem diameter, plant population and fresh and dry matter yields were recorded. The results showed that the solid set system significantly increased ($P \leq 0.05$) the stem diameter with 31%, number of leaves per plant with 13%, plant population with 14% and fresh forage yield with 17%. However, the difference was not significant between the two irrigation systems on plant height and dry matter yield. With respect to both cultivars, the results also showed that there was no significant difference ($P > 0.05$) in the studied parameters. The results of this study indicated the superiority of the solid set system over the basin irrigation system. This may be attributed mainly to the intermittent application of the appropriate watering demands.

Keywords: Semi portable solid set sprinkler; Maize; Basin irrigation.

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INTRODUCTION

Maize (*Zea mays* L.) is one of the most important plants worldwide, because of its high grain and forage yield. Maize has its vital significance because it has wide environmental range and biological efficacy. In Sudan maize is a promising cereal crop with potential usefulness for human and livestock (Salih *et al*., 2008). It ranks fourth in importance in the cereal crops in Sudan after sorghum, wheat and pearl millet. It is grown in small scales under rainfed conditions in Kordofan and Darfour, in larger scales under irrigation in Northern States and under flood irrigation in Kassala state (Ali ,1991). Maize is very sensitive to water stress (Pandey *et al*., 2000; Cakir, 2004). Maize requires 550-650 mm irrigation water for proper growth and development depending upon environmental conditions (Reddy, 2006).

Effective irrigation will influence the entire growth process from seedbed preparation, germination, root growth, nutrient utilization, plant growth and regrowth, yield and quality. The traditional surface irrigation systems generally have low irrigation performance due to several problems, including non-leveled land and poor irrigation management. However, surface irrigation performance could be improved when adopting well-designed and managed systems and appropriate irrigation scheduling (Pereira *et al*., 2002). Sprinkler irrigation system is defined as a pressurized system where water is distributed through a network of pipelines to the field and applied through selected sprinkler heads or water applicators. The system includes many types like solid set system, semi-permanent and continuously moving systems. They are characterized by a high overall efficiency. Solid set sprinkler irrigation systems are those in which sprinklers, with their assorted riser, lateral, and manifold pipes, are placed in a regular pattern over the entire irrigated area. Solid set sprinkler systems may be permanent or may be set in place only during a crop growing season (Smajstrla *et al*., 2005).

In Sudan, surface irrigation is the dominant method used in the major irrigated schemes. With the increasing water scarcity, there is need to optimize water use mainly for irrigation purposes by using more efficient irrigation systems such as sprinkler and drip which are characterized by high crop water productivity. In Sudan, many studies have been carried

out to determine maize yield under different surface irrigation levels. But studies on the effect of sprinkler irrigation system on yield of maize are scanty. Therefore, the objective of this study was to study the effect of solid set sprinkler irrigation system as compared to the surface irrigation system (basin) on growth and yield attributes of maize for forage production.

MATERIALS AND METHODS

A field experiment was carried out during season 2007 /2008 at Elailafoon area 30 km south east of Khartoum on the eastern bank of the Blue Nile.It is confined between 15°27'N and 32°46'E, with an altitude of 389 m above mean sea level.

The soil of the experimental site is clay, with pH of 8.23. Soil infiltration rate was measured using the double ring infiltrometer. The average infiltration rate was 4.8mm/h.

The treatments consisted of two irrigation systems (solid set sprinkler and basin) and two maize cultivars (Mugtama 45 and Baladi), and they were arranged in nested design with three replicates.

The land was first prepared using chisel plough to a depth of 25 cm, then disc harrowed (16 discs) to break the clods. The planting operation in the solid set system of the two maize cultivars was carried out by planter (70 cm spacing between rows and15 cm spacing between seeds).In the basin system, the planting operation was done manually. The dimensions of basins were 4 m x 5 m. Thinning was carried out two weeks after seedling emergence. NPK fertilizer was applied in split dose. A semi portable solid set sprinkler irrigation system was installed at the location and its components are shown in Fig.1. A submersible electric pump type was used for pumping water to the system. The number of irrigations of each system was recorded at the end of the season. For the basin system the number of irrigations was 13 and 22 for the solid set sprinkler system. The water applied by the solid set system during the season was 607 mm.
The following growth and yield attributes were studied:

Plant height (cm)
Five plants were chosen at random from each plot. Plant height for each plant was taken from the base of the plant to the top using a metering device. The mean height of the five plants was recorded.

Number of leaves per plant
Five plants were randomly selected and number of leaves in each selected plant was counted. The mean number of leaves per plant was obtained.

Stem diameter (mm)
Five plants were randomly selected and the stem diameter of each plant was measured using a vernia. The mean stem diameter of the five plants was recorded.

Plant population
From each plot the number of plants in a square meter was counted, and the mean number for plant population in a square meter was obtained.

Fresh and dry matter yields (kg/m2)
Plant from each plot were cut at the ground level and weighed in the field to obtain the fresh weight. From the same plot, plants number were determined in a square meter and air dried, then weighed to obtain dry matter yield.

The Analysis of variance (ANOVA) was applied for data. Means were separated using the least significant difference (LSD) procedure.

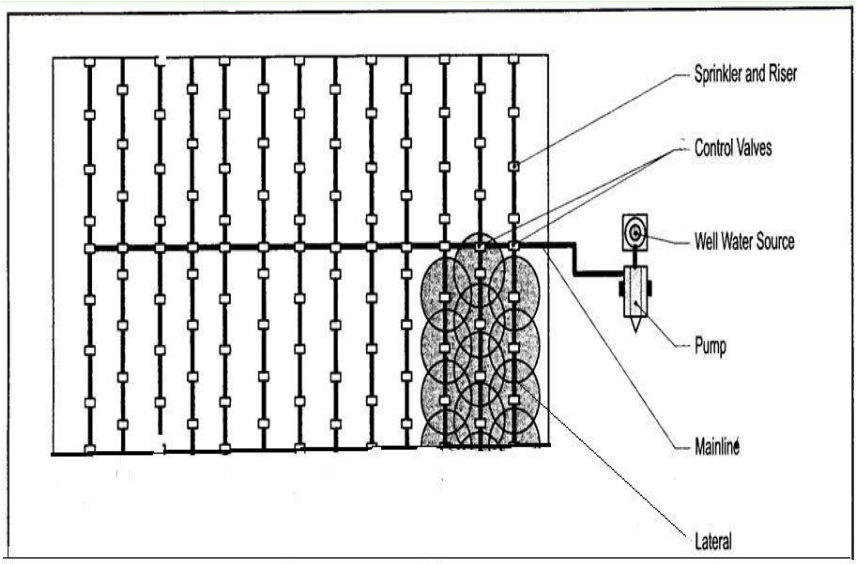

Fig.1.Components of semi-portable solid set system

RESULTS

Table 1 shows the effect of the two irrigation systems on plant height of the two maize cultivars**.** There were no significant differences between the two irrigation systems and between the two maize cultivars in plant height. Both solid set sprinkler system and Baladi cultivar gave the tallest plants as compared to the basin system and Mugtama 45 cultivar.

Table 1. Effect of the two irrigation systems on plan height of maize cultivars

Treatment	Basin	Solid set	Mean
V1	148.2	141.2	144.7 [a]
V2	140.7	158	149.3 [a]
Mean	144.4 [a]	149.6 [a]	

V1 = Mugtama45 , V2 = Baladi
Means within columns and rows with the same letter are not significantly different at $P \leq 0.05$.

Table 2 illustrates the effect of the two irrigation systems on stem diameter of the two maize cultivars. A significant difference in stem

diameter of maize was detected between the two irrigation systems. The solid set sprinkler system gave the highest value in stem diameter. There was no significant difference between the two maize cultivars on stem diameter.

Table 2. Effect of the two irrigation systems on stem diameter of maize cultivars

Treatment	Basin	Solid set	Mean
V1	9.3	11.6	10.4 [a]
V2	9.1	12.6	10.8 [a]
Mean	9.2 [b]	12.1 [a]	

V1 = Mugtama45 , V2 = Baladi
Means within columns and rows with the same letter are not significantly different at $P \leq 0.05$.

The effect of the two irrigation systems on the number of leaves per plant of the two maize cultivars is presented in Table 3. The solid set as compared to the basin significantly increased the number of leaves per plant. No significant differences were found between the two maize cultivars in the number of leaves per plant.

Table 3. Effect of the two irrigation systems on number of leaves per plant of maize cultivars

Treatment	Basin	Solid set	Mean
V1	12	13.2	12.6 [a]
V2	11.7	13.5	12.65 [a]
Mean	9.2 [b]	12.1 [a]	

V1 = Mugtama45 , V2 = Baladi
Means within columns and rows with the same letter are not significantly different at $P \leq 0.05$.

Table 4 reveals the effect of the two irrigation systems in plant population of the two maize cultivars. The plant population was significantly affected by the two irrigation systems. The solid set system scored the highest value in plan population. There was no significant difference between the two maize cultivars in plant population.

Table 4. Effect of the two irrigation systems on plant population of maize cultivars

Treatment	Basin	Solid set	Mean
V1	14	16.2	15.1 [a]
V2	13.5	17.2	15.4 [a]
Mean	13.7 [b]	16.7 [a]	

V1 = Mugtama45 , V2 = Baladi
Means within columns and rows with the same letter are not significantly different at $P \leq 0.05$.

The effect of the two irrigation systems on fresh forage yield of the two maize cultivars is presented in Table 5. The solid set sprinkler system significantly increased the maize fresh forage yield. No significant differences between the two maize cultivars on fresh forage yield.

Table 5. Effect of the two irrigation systems on fresh weight of maize cultivars

Treatment	Basin	Solid set	Mean
V1	2.2	2.8	2.5 [a]
V2	2.3	2.6	2.4 [a]
Mean	2.2 [b]	2.7 [a]	

V1 = Mugtama45 , V2 = Baladi
Means within columns and rows with the same letter are not significantly different at $P \leq 0.05$.

Table 6 shows there were no significant differences on dry weight between the two irrigation systems and the two maize cultivars. However, both solid set sprinkler system and Mugtama 45 cultivar recorded higher values on dry matter yield as compared to the basin system and Baladi cultivar.

Table 6. Effect of the two irrigation systems on Dry weight of maize cultivars

Treatment	Basin	Solid set	Mean
V1	1.2	1.4	1.3 [a]
V2	1.2	1.3	1.2 [a]
Mean	1.2 [a]	1.35 [a]	

V1 = Mugtama45 , V2 = Baladi

Means within columns and rows with the same letter are not significantly different at $P \leq 0.05$.

DISCUSSION

Applying the correct amount of water is particularly critical for crops that are sensitive to water stress. In this study, the growth and yield attributes of the two maize cultivars differed in their response to the two irrigation systems. Plant height of the two maize cultivars was not affected by the two irrigation systems. This insignificant difference could be attributed to the fact that the amount of water applied by both systems has small effect on internodes elongation. Similar findings were observed by Abdelgadir (2002).

The positive effect of the irrigation by the solid set system in stem diameter, number of leaves per plant and plant population could be attributed to the frequent irrigation applied by solid set sprinkler system, which in turn maintained the soil moisture content in the active root zone close to field capacity. The result in accord with Yazar *et al.*(1999) results, who reported that irrigation water amount and irrigation frequency improved and increased maize growth and grain yield.

The difference between the two irrigation systems in fresh yield of maize in this study could be attributed to the frequent irrigation water applied by the solid set sprinkler system as well as the application of irrigation water by this system has beneficial effects on the microclimate of the irrigated area, resulting in reduced transpiration by crop and other positive physiological effects. Similar findings were reported by Humphreys *et al.* (2005), who reported that the sprinkler system when compared to the surface system resulted in increase of maize yield.

The two irrigation systems had no significant effect on dry weight of the two maize cultivars. However, there was increasing trend in maize dry weight under the solid set sprinkler system. The result agrees with the results of Karasahin (2014), who found that maize dry weight was not affected under different irrigation methods.

CONCLUSION

It can be concluded from the results of this study that the solid set sprinkler irrigation system significantly increased maize stem diameter, number of leaves per plant, plant population and fresh forage yield when compared with the basin irrigation. The frequent irrigations applied by solid set system had a positive effect on the performance of maize.

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تأثير نظام الري بالرش شبه المتنقل على سمات النمو و الإنتاجية لمحصول الذرة الشامي (*Zea mays* L.) *

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مستخلص البحث: أجريت التجربة بمنطقة العليفون (جنوب شرق الخرطوم) على الضفة الشرقية للنيل الأزرق خلال موسم 2007 و 2008. كان الهدف دراسة تأثير نظام الري بالرش شبه المتنقل بالمقارنة بنظام الري السطحي بالأحواض على سمات النمو و الإنتاجية لمحصول الذرة الشامية للعلف. المعاملات مكونة من نظام الري بالرش شبه المتنقل و نظام الري بالأحواض مع صنفي ذرة شامي (مجتمع 45 و بلدي). نظمت المعاملات بإستخدام تصميم نستد بثلاثة مكررات. تم تحليل خواص التربة الفيزيائية و الكيميائية لموقع التجربة. سجلت البيانات حول طول النبات، عدد الأوراق للنبات الواحد، قطر الساق، كثافة النبات وإنتاجية الوزن الرطب والمادة الجافة. أظهرت نتائج التحليل أن نظام الري شبه المتنقل أدي إلي زيادة معنوية ($P \leq 0.05$) في قطر الساق بنسبة 31% ، عدد الأوراق للنبات الواحد بنسبة 13%، كثافة النبات بنسبة 14% و الوزن الرطب بنسبة 17%. غير أن الفرق كان غير معنوي بين نظامي الري على طول النبات وإنتاجية المادة الجافة.فيما يتعلق بصنفي الذرة الشامية أيضاً أظهرت النتائج عدم وجود فرق معنوي ($P > 0.05$) في الصفات المدروسة. دلت نتائج هذه الدراسة على تفوق نظام الري بالرش شبه المتنقل على نظام الري بالأحواض ويعزى هذا أساساً للإضافة المتقطعة لمتطلبات الري المناسبة.

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* جزء من رسالة ماجستير قدمها الؤلف الأول لجامعة الخرطوم

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