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Effect of Different Towers of Center Pivot Irrigation System on Wheat Production Under River Nile State Conditions

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Abstract

The experimental work was carried out during two growing seasons 2017-2018 and 2018-2019. It consisted evaluating the performance of different towers of center pivot irrigation system and their effect on crop growth and yield. The treatments used were distance of tower from the pivot. The experiment was arranged in complete randomized block design with three replications. Wheat crop was used as indicator, the crop parameters measured were number of leaves/plant, plant height, plant density, stem diameter, Spike length and yield. For testing the performance of center pivot system, a 280 catch cans with same specifications were used to collect water applied by the nozzles, where the system allowed completely pass over them. The results revealed that the general uniformity coefficient and uniformity of distribution of the center pivot irrigation system were found to be 75% and 64% respectively. Also the results indicated that the maximum plant height was found under towers number 1 and 2 as the same value of 74.3 cm. While the towers number 4, 2 and 3 gave the highest number of leaves/ plant. Tower number 3 and 4 gave the highest stem diameter as 0.2 cm. The tallest spike and number of plants per plot were 10.33 cm and 529.33 plant/m^2 found under tower number 4. The results of this study can help users to improve the performance of center pivot irrigation system.

Keywords

Center Pivot, Conventional System, Irrigation System, Tower, Wheat, Yield

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1. Introduction

The major constraints to produce more food to meet the increasing demands of the world population are land and water [1]. One possible approach to conserve these scarce resources may be through improving the performance of the existing irrigation projects. Globally, water amount required of the wheat has been received considerable attention as one of the key factors affecting wheat yield. Presently, the area of land that oriented for the wheat in Sudan are grown under conventional farming system and are suffering from shortage of irrigation water and, therefore, productivity considered is low without used right technical packages. However, the total amount of water per season for wheat crop needs to optimize for better productivity in the developing countries. Irrigation uniformity is linked to crop yield through the effects of under or over irrigation. Inadequate water results in high soil moisture tension, plant stress and reduced crop yields, whilst excess water may also reduce crop yield through mechanisms such as leaching of plant nutrients, increased disease

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incidence or hindered growth of commercially valuable parts of crops [2]. Center pivot irrigation have many characterizes are high uniform and efficient water applications, high degree of automation, and ability to apply water and nutrients over a wide range of soil [3]. The traditional surface irrigation systems generally have low irrigation performance due to several problems, including non-levelled land and poor irrigation management [4]. However, surface irrigation performance could be improved when adopting well-designed and managed systems and appropriate irrigation scheduling [5, 6]. The yield of wheat under center pivot irrigation was higher than the surface irrigation [7]. There were some problems facing the use of centre pivot irrigation system under the local conditions [8]. Therefore, the present investigation was evaluating the performance of different towers of center pivot irrigation system and their effects on crop growth and yield.

2. Materials and Methods

The experimental work was carried out during two seasons 2017/2018, 2018/2019. It consisted evaluating the performance of centre pivot irrigation system in Atbara food security irrigation project. Which is one of four food security projects associated with the implementation of River Nile State. The project area is about 2000 Feddan, it lies on the east side of the River Nile confined between lat. 17°55′ and 17°58′ N and long 31-06 – 08 and 31 – 13 – 31E. The area of the project lies in a desert climate of an average annual rainfall of 12 mm (occurring mainly in July – August). The mean daily temperature is about 37°C and the mean minimum temperature is 22°C. The mean annual temperature is 29°C. The irrigation network consists of a main canal taking water from a pump station situated on the east bank of the River Nile.

The treatments used were tower rank from the pivot. The experiment was arranged in complete randomized block design with three replications.

For testing the performance of system center pivot irrigation system, a 280 catch cans with same specifications were used to collect water applied by the nozzles, where the system allowed completely pass over them. The cans were placed at uniform distances (5 m) in a straight line arranged from the pivot point towards the outward direction. To determine the volume of water that collected from cans, measuring cylinders, was used.

Uniformity coefficient (CU)

Christiansen's coefficient of uniformity (CU) expressed as a percentage was determined as expressed by [7, 3] as following equation (1):

$$CU = (1 - \frac{D}{M}) \times 100 \quad (1)$$

Where:

CU = Christiansen's coefficient of uniformity (%).

D = Average absolute deviation from the mean application rate, (mm).

M = Average application rate, (mm).

Distribution uniformity or pattern efficiency (DU):

The distribution uniformity is computed by dividing the average low quarter caught in the cans by the average depth caught in all cans. This is expressed by equation (2) as suggested by [9].

$$DU = \frac{Average\ low\ quarter\ caught\ in\ the\ cans?}{Average\ depth\ caught\ in\ all\ cans} * 100 \quad (2)$$

Where:

DU = Distribution uniformity (%)

The crop parameters measured were no. of leaves/plant, plant height, plant density, stem diameter, spike length and yield, for each 2 m by 2 m subplot were measured periodically. Measuring type, sensitive balance and square sampling ring were used.

The statistical analysis of data and derived variables from the experiment was performed using the statistical package SAS™ (Statistical Analysis System computer program Software) (SAS Institute, Cary, NC, USA), version 2004 was used to analyses the collected data. The analysis of variance (ANOVA) technique was conducted to determine differences between treatments for each parameter as applicable to split-plot design. Treatment means were compared with least significant differences (LSD) procedure at 0.01 and 0.05 probability level.

3. Results and Discussion

Uniformity coefficient

As the data presented in table 1. the tower had significantly affected the uniformity coefficient under two level of significant. The highest value was recorded in first tower, followed by 4, 6, 3, 2 and 5. While the tower number 7 gave the lowest value. The low values of Uniformity coefficient of tower number 5 can be attributed to clogging of nozzles caused by sedimentation, trashes and/or nozzle being worn out and inaccurate setup of the system.

The general uniformity coefficient of the investigated area was found to be 75%. These results were agree with result obtain by [10, 11] who found similar trend who recommended that a good uniformity coefficient lies within a

range 81.5% - 96.8%. The result was contrary to those obtained by [12]

Table 1. Effect of different towers on system performance.

Tower No.	CU%	DU%
1	85a	59abc
2	75ab	74ab
3	774ab	73ab
4	81a	73ab
5	69ab	55bc
6	78ab	72ab
7	57b	42c
LSD	22.3	18.9
c.v.%	12.2	12.05

Means with the same letter are not significantly different

Distribution uniformity (DU)

Table 1. Shows no significant different among towers. The greatest value was registered under tower no. 2, whereas tower number 7 recoded the minimum value, this may be the fact that all part of the soil received an equal water depth. The general Uniformity distribution of this study area was found to be 64% The result obtained is disagrees with those obtained by [13, 14] and agreed with results obtain by [15, 16, 17] who coated that the center pivot systems are generally operating at very low levels of performance.

Plant height

Table 2. shows that the difference in plant height per plot, among the different towers is significant under the two levels of significance. The maximum value was found under tower number 1 and 2, followed by 4, 5 and 3. While 6 and 7 released the lowest value. Towers number 1, 2, 3, 4 and 5 were statistically similar and differed from other towers. This is not good indicator to that, there is difference in plant height which can be due to inhomogeneity of the crop height, under center pivot irrigation system. This result was inconsequent with [13] who found that tower did not affected plant height.

Table 2. Effect of different towers on plant growth and yield.

Tower No.	No. of leaves/plant	Plant height (cm)	Plant density (plant/m^2)	Stem diameter (cm)	Spike length (cm)	Yield (Ton/ha)
1	0.13	74.3a	450abc	0.13	9.17ab	13.65
2	4.7	74.3a	476.67ab	0.17	9.43ab	15.69
3	4.7	69ab	454.67abc	0.2	9ab	16.59
4	5	70ab	529.33a	0.2	10.33a	13.81
5	4	70ab	404abc	0.17	9ab	16.73
6	4.3	63.7b	366.67bc	0.17	9.23ab	15.55
7	4.3	63.7b	320c	0.17	8.67b	13.15
LSD	1.35	0.09	145.14	0.09	1.47	4.04
C. V.%	17	8.5	19.04	27.3	8.99	15.19

Means with the same letter are not significantly different

Number of leaves/plant

As illustrated in table 2. Number of leaves did not affect by towers. Tower number 4 gave the highest no. of leaves/ plant, followed by 2, 3.6.7 and 5. Whereas tower number 1 ranked last. This result may be due mainly to the even water distribution by the center pivot system under all towers.

Stem diameter (cm)

Stem diameter did not affect by towers as shown in table 2. Towers number 3 and 4 gave the highest Stem diameter, followed by 2, 5, 6 and 7. Whereas tower number 1 ranked last. This result may be attributed mainly to the highly uniform distribution of water by the center pivot system.

Spike length (cm)

Data recorded in table 2. mentioned that the spike length was significantly affected by towers under level of significant ($p \leq 0.05$). The tallest spike was seen in tower number 4, followed by 2, 6 and 1. While tower number 7 gave the shortest spike. This may due to un even distribution of along center pivot irrigation lateral. The tower number 1 was statistical differ from tower number 7. While similar to others, but those tower were statistically similar. This may be due to the amount of water which resaved by plant grown in tower number 7 did not meet the crop water requirement, or may be due to the fertile distribution not equal along the lateral

Plant density

Table 2. shows that there was a highly significant difference in the number of plants per plot among the different towers under the two levels of significance, It was found that tower number 4 had the largest number of plants per plot then the towers 2, 3, 1, 5, 6 and, the last tower 7 showed the lowest number of plants which can be due to the same reason as most of the other parameters. Further analysis was done to reveal which of tower had the largest production. The last tower showed the lowest productivity which can be attributed to that the last tower requires high pressure and great discharge whereas the pressure is found to be less due to that along the tower outwards, the friction losses increase, this requires that nozzles should be adapted to compensate for the

amount of water lost by friction.

Yield of the crop in ton/ha

Results in table 2. showed that there is no significant difference between the productivity of towers. The greatest yield was recorded in tower number 5 as (16.73 ton/ha), followed by other towers except tower number 7 which register the lowest yield (13.15 ton/ha). Similar result was stated by [7] who found yield of crops irrigated under center pivot irrigation system was higher than those irrigated under surface irrigation system.

4. Conclusions

A center pivot irrigation system was used to evaluate the performance of different towers through crop growth and yield of wheat crop production. The results showed that, the highest Plant height, number of leaves/ plant, spike and number of plants per plot were 74.3 cm, 5, 10.33 cm and 529.33 plant/m^2, respectively. While, the overall uniformity coefficient and distribution uniformity of irrigation system were 75% and 64%. The findings are highly useful for the farm owners when using the center pivot irrigation system with wheat crop.

References

[1] Fróna, D., Szenderák, J. and Harangi-Rákos, M., 2019. The Challenge of Feeding the World. Sustainability, 11 (20), p. 5816.

[2] Solomon, K. H., 1990. Sprinkler Irrigation Uniformity, Center for Irrigation Technology, USA. Accessed on 11th May 2007 from cati.csufresno.edu/CIT/rese/90/900803/index.html

[3] El Nahry, A. H., Ali, R. R., Baroudy, A. A., 2011. An approach for precision farming under pivot irrigation system using remote sensing and GIS techniques. Agricultural Water Management, 98: 517-531.

[4] Teshome, Y., Biazin, B., Wolka, K. and Burka, A., 2018. Evaluating performance of traditional surface irrigation techniques in Cheleleka watershed in Central Rift Valley, Ethiopia. Applied Water Science, 8 (8), p. 219.

[5] Darouich, H.; Gonçalves, J. M.; Muga, A.; Pereira, L. S., 2012. Water saving vs. farm economics in cotton surface irrigation: An application of multi criteria analysis. Agric. Water Manag. Pp. 115, 223–231.

[6] Fernández García, I., Lecina, S., Ruiz-Sánchez, M. C., Vera, J., Conejero, W., Conesa, M. R., Domínguez, A., Pardo, J. J., Léllis, B. C. and Montesinos, P., 2020. Trends and Challenges in Irrigation Scheduling in the Semi-Arid Area of Spain. Water, 12 (3), p. 785.

[7] Basheer, A. K., Ali A. BM., Elshaikh N. A., Alhadi M. and Altayeb, O. A., 2015. Performance's Comparison Study Between Center Pivot Sprinkler and Surface Irrigation System. International Journal of Engineering Works. Vol. 2, Issue 2, PP. 23-27.

[8] Elzubeir, A. O., 2018. Survey Study of Centre Pivot Irrigation System in Northern State (Sudan). International Journal of Science and Qualitative Analysis, 4 (1), p. 27-33.

[9] ASABE, 2007. Test procedure for determining the uniformity of water distribution of centerpivot and lateral move irrigation machines equipped with spray or sprinkler nozzles. ANSI/ASAE S436.1 JUN 1996. ASAE Standards, pp. 1033-1039.

[10] Mustafa, R. H., Elgali, M. B. and Abulgasim, S., 2013. "Trends in wheat production and consumption in Sudan", International Journal of Research in Management, Economics and Commerce, vol. 3, no. 4, pp. 44-56.

[11] Elhassan, Z. A., 2008. Assembling and Performance Evaluation of center pivot irrigation system New Hamdab Irrigation Project Northern State Sudan. Msc,(Agric) thesis, University of Khartoum.

[12] Basheer, A. K., Ali, A. B., Elshaikh, N. A., Alhadi, M. and Altayeb, O. A., 2015. Performance's Comparison Study between Center Pivot Sprinkler and Surface Irrigation System. t J. Eng. Works, 2, pp. 6-10.

[13] Ali, M. A. E, 2004. Technical Evaluation of Centre Pivot Irrigation System for Lucme (Medicago sativa) Production in the River Nile State. M. Sc. Thesis, Faculty of Agriculture, University of Khartoum.

[14] Al-Gaadi, K. A., Hassaballa, A. A., Tola, E., Kayad, A. G., Madugundu, R., Assiri, F., Edrris, M., Alameen, A. and Edrees, H., 2019. Impacts of center pivot irrigation system uniformity on growth of potato crop and residual soil nitrogen. International Journal of Agricultural and Biological Engineering, 12 (1), pp. 126-131.

[15] Mustafa, H. A., 2004. Evaluation of center pivot and linear move sprinkler irrigation system. M.Sc Thesis Dep. of Agric. Engineering, Faculty of Agricultural, University of Khartoum.

[16] Abedinpour, M., 2017. Field evaluation of centre pivot sprinkler irrigation system in the North-East of Iran. JOURNAL OF WATER AND LAND DEVELOPMENT. No. 34 (VII–IX): 3–9.

[17] Hawait ALLah. EL., 2015. Technical Evaluation of performance of center pivot sprinkler Irrigation System at West Omdurman. Sudan. Master of Science in agriculture Engineering theses Sudan University.