Benha University
Faculty of Agriculture

Institute for Agricultural Technology

REPORT

INTRODUCED FROM

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FACULTY OF AGRICULTURE-BENHA UNIVERSITY

EGYPT

SEPTEMBER, 2014

CONTENTNS

1. GENERAL

This report will be introduced to Benha University about the research visit to Germany from March to September, 2014. The research proposal accepted from the German side to do it during summer 2014. The full financial support for this research visit (six months) covered by the Egyptian Academy of Scientific Research and Technology.

2. NOMINATED SCIENTIST INFORMATION

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3. HOST INFORMATION

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4. SUBJECT OF STUDY

Irrigation systems have to be properly designed with a reasonably uniform water application with assurance of return of the capital invested, because their initial cost is very high. Another point to be studied is the management of the system. For instance, flow or pressure regulators are used to obtain within reasonable limits uniform applications of water from all the sprinklers operating in a field. They can overcome the problem of excessive pressure-head variations resulting from sloping surfaces and pressure-head losses. In consequence, mainly the sprinklers and sprays must be changed when they are out of order or lost the efficiency. This is the main objective of this study: to evaluate the installed center pivot system and make the essential changes and modifications for obtaining higher efficiency.

5. INTRODUCTION

Center-pivot irrigation systems have experienced a wide diffusion worldwide because of their advantages relative to other irrigation systems such as: (i) high potential for uniform and efficient water applications, e.g., when the system is properly designed and managed more than 90% of water applied can be utilized by the crop; (ii) high degree of automation, which allows applied precision farming practices including variable rate technology; and (iii) ability to apply water and nutrients over a wide range of soil, crop and topographic conditions. A main disadvantage of center-pivot is high water application rates, which can cause runoff, mainly in undulating land areas. Runoff is undesirable because it represents a non-beneficial water use that may lead to soil erosion, crop yield reductions and contamination of water bodies when transporting agricultural chemicals (Duke and Perry, 2006; Marques da Silva and Silva, 2008; King et al., 2009; El Nahry et al., 2011).

Efforts to improve center-pivot design and management have concentrated on increasing water application uniformity, reducing energy use by operating with lower pressure, and controlling negative environmental impacts such as excessive water and fertilizer operational losses.

When a system has low distribution uniformity water and economic productivity are low (Rodrigues and Pereira, 2009); it may be required to apply a higher water depth to ensure that the entire crop receives the minimum depth necessary to meet the crop water requirements. This implies higher water and energy costs and detrimental impacts on the environment. Rodrigues et al. (2010) have shown that improving irrigation performance leads to an increase in the energy gains in relation to the amount of water use. With the attempt of reducing pressure requirements, new spray sprinklers have been developed in recent years, hence replacing traditional impact sprinklers. Low-pressure spray sprinklers can be classified as Fixed Spray Plate Sprinkler (FSPS) and Rotating Spray Plate Sprinklers (RSPSs). Several studies demonstrated that RSPS sprinklers lead to better performance than FSPS (DeBoer, 2002; Montero et al., 2002; Clark et al., 2003). Faci et al. (2001) recommended using narrow sprinklers spacing to improve overlapping and uniformity. Playán et al. (2004) compared wetted diameters, water application and wind drift and evaporation losses from FSPS and RSPS and concluded that RSPS are advantageous relative to FSPS. This is confirmed by results presented of Ortiz et al. (2010), who compared RSPS and FSPS placed at 2.5 and 1.0 m above the ground and found that RSPS achieved higher water application uniformity.

6. MATERIALS AND METHODS

A center pivot machine was tested on a sandy loam soil in the experimental station of the Thünen Institute for Agricultural Technology, during summer 2014. The experimental center pivot machine used had two spans of 38.35 m each, and with an overhang of 13.30 m. Thus, the total length was 90 m giving a total irrigated area of 2.54 ha.

A series of experiments were performed following the ASAE S436.1 standard to determine the water application pattern of sprinklers under different nozzle arrangements and deferent speeds. The Nelson R3000 sprinklers were selected for the experiments. The main sprinkler characteristics of the centre pivot are shown in Table (1).These sprinklers used a rotating red and green plate (Table 2). Nozzle diameters were 1.7 to 4.7 mm.

In all cases the sprinklers had pressure regulators with output pressure set to 172 kPa (1.72 bar), and the pressure at the fixed pivot point was 250 kPa (2.5 bar).

Table 1: Main sprinkler characteristics of center pivot system.

	Distance from center pivot (m)	Nozzle diameter (mm)	Spacing among sprinklers (m)	Discharge (m^3/h)
Span I	0-38.35	1.7 - 2.9	2.55	0.15-0.44
Span II	38.35- 76.70	3.1 - 3.7	2.55	0.50-0.71
Overhang	76.70 - 90	3.7- 4.7	2.55	0.71-1.20

Table 2: The description of the sprinklers plate type (Nelson Irrigation. 2014)

Sprinkler Plate Type	Description	Pressure Range	3TN Nozzle Range		Throw Diameter Data (No Wind Tests)
			Minimum	Maximum	
 D4-8° GREEN PLATE	**FOR DROP TUBE APPLICATIONS** Utilizes 4 low-trajectory streams for maximum coverage and wind-fighting ability.	20-50 PSI 1.4-3.4 BAR	#14 @ 30 PSI (2.0 BAR) #16 for lower pressures	#50	Coverage @ **30 psi** (2.0 BAR) #32 Nozzle Mounting Ht. / Throw Diameter **9 ft.** (2.7 M) —— **72 ft.** (21.9 M) **6 ft.** (1.8 M) - - - - **64 ft.** (19.5 M)
 D6-12° RED PLATE	**FOR DROP TUBE APPLICATIONS** 6 medium-trajectory, diffused streams provide droplet breakup with low stream height.	15-30 PSI 1.0-2.0 BAR	#14 @ 15 PSI (1.0 BAR)	#50	Coverage @ **25 psi** (1.7 BAR) #36 Nozzle Mounting Ht. / Throw Diameter **9 ft.** (2.7 M) —— **66 ft.** (20.1 M) **6 ft.** (1.8 M) - - - - **58 ft.** (17.7 M)

In the pivot experiments, two rows of collectors were located at 1m spacing along the pivot radius and 0.4 m height used to determine applied water depth (Fig. 1). Collectors were conical in shape and graduated in millilitres (rain gauges).

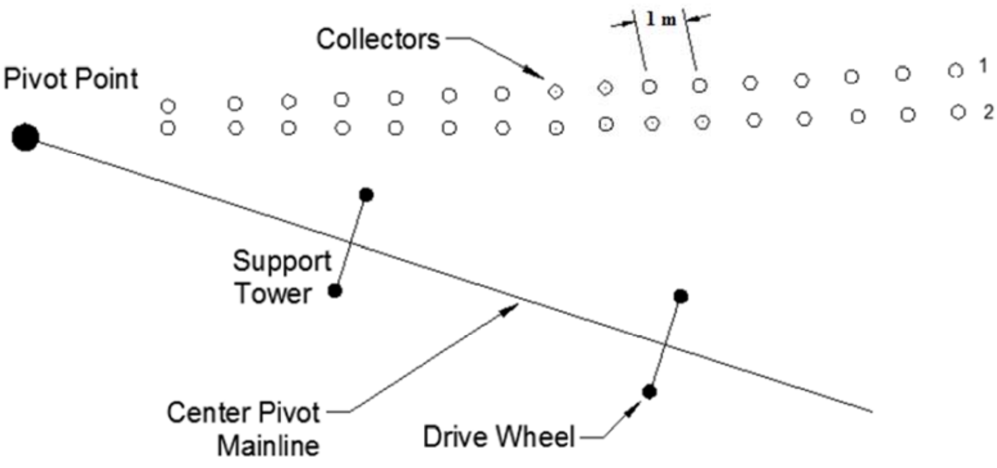

Fig.1: Center pivot uniformity test collectors positioned at an equal distance of 1 meter

The Christiansen uniformity coefficient (Keller and Bliesner, 1990) can be used for determining travelling path uniformity:

$$CU_c = 100 \times \left[1 - \left(\frac{\sum_{i=1}^{n} |d_i - \bar{d}|}{n\bar{d}} \right) \right]$$

Where

CU_c is the Christiansen uniformity coefficient

d_i is the collected water depth in the ith collector

$\bar{d}$ is the arithmetic average of the water collected.

n is number of collectors located in the circular path of a pivot lateral point.

Radial and travelling path uniformities represent different phenomena. Radial uniformity results from all spray sprinklers mounted on the lateral. Travelling path uniformity comes from a limited number of spray nozzles overlapping at a certain point along the lateral.

All tests are done under good weather conditions, where there are no rains and low wind speed (0-3 m/sec).

7. RESULTS AND DISCUSSION

Table 3 lists the main results from each individual field test, including the nozzle/plate configuration, pressure, speed, average wind speed, average rate, and Christiansen uniformity.

The first category (Test 1) was to evaluate the original design as set up by the producer. The center pivot was tested with three deferent speeds (16, 21, and 30%) to irrigate with 100, 70, and 50 % of the plant requirements (Maiz). Figure (2) shows the main results of the water distribution along the pivot lateral. The water distribution was bad for the first span but was good for the second span. The reason for non-uniformity, because of the wrong arrangement of nozzles for the first span. All nozzles had the same diameter (3.1 mm) and the distance was about 2.55 m from each other. With the same trend, the coefficient of uniformity along the pivot was bad according to the standard as shown in table (3).

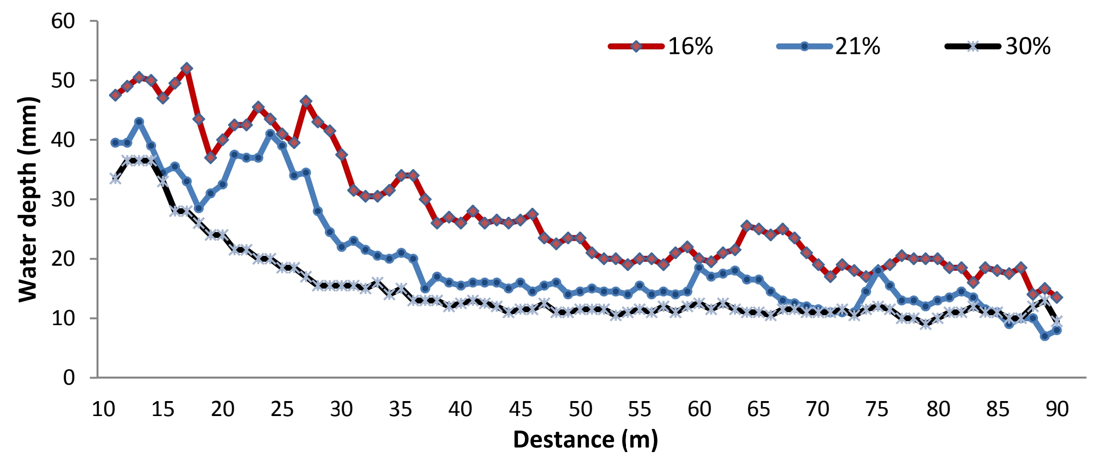

Fig. (2): Water distribution along center pivot at deferent speeds (Test1)

Table (3): Summary of average irrigation depth and CU of each test

Experiment	Speed (%)	Average depth applied (mm)	CU (%)	Comments
Test1 (Original)	16	28	67.5	Wind speed 0-2 m/s, applied water 18.3 m^3/h, pressure at center point 2-2.7 bar
	21	19.75	60.9	
	30	14.9	67.3	
Test 2	Green 20	19.75	86.47	nozzles' rearrangement are 1.9 to 2.9 mm, wind speed 0-2.2 m/s, pressure at center point 2.5 bar
	Green 30	11.26	85.70	
Test 3	Red 20	22.6	91.08	
	Red 30	11.73	88.33	
Test 4	Red 20	20.97	84.31	nozzles' rearrangement are 1.7 to 2.9 mm, wind speed 0-1.6m/s, pressure at center point 2.3-2.6 bar
	Red 30	12.14	86.18	
Test 5	Green 20	19.04	89.09	
	Green 30	11.7	86,86	

<u>The second category (Test 2 and 3)</u>

Because of the high water applied at the first span in the first category, these two tests evaluated application uniformity of the pivot with the nozzles' rearrangement in the first span and compared between the red and green plates under 20-30% of full speed (Table 3). The CU for this category was 85.7 to 91.08%. These values indicate the center pivot was performing in the good to excellent range according to Harrison and Perry (2013). The red nozzle plats showed a high uniformity coefficient than the green plats especially under 20% of the full pivot speed.

<u>The second category (Test 4 and 5)</u>

Still there are some problems affect the application depths. For these tests the smaller nozzles were switched for the first span, as described in table 3. The CU for this category was 84.31 to 89.09%. These values indicate the center pivot was performing in the good range according to Harrison and Perry (2013). The green nozzle plats showed a high uniformity coefficient than the red plats especially under 20% of the full pivot speed.

Even with a high 80's uniformity coefficient, the center pivot is performing well unless the problem may be obvious, i.e. a wrong nozzles order (Harrison and Perry, 2013). Some indication of how sprinklers affect the application depths is shown in a comparison of figs. 3 4, 5 and 6. These four graphs show that higher application depth occurred near the center pivot point and lower application depth occurred at the end of the overhang.

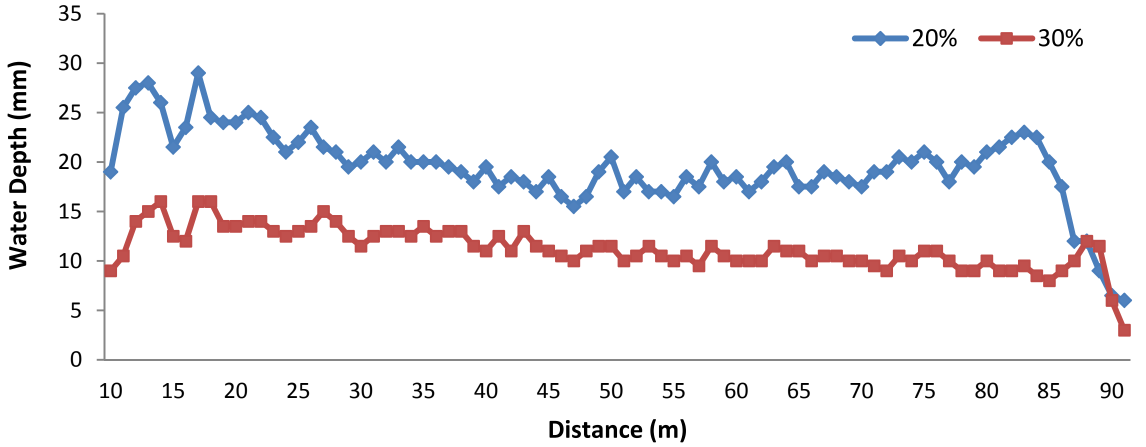

Fig. (3): Water distribution along center pivot with green plates (Test 2)

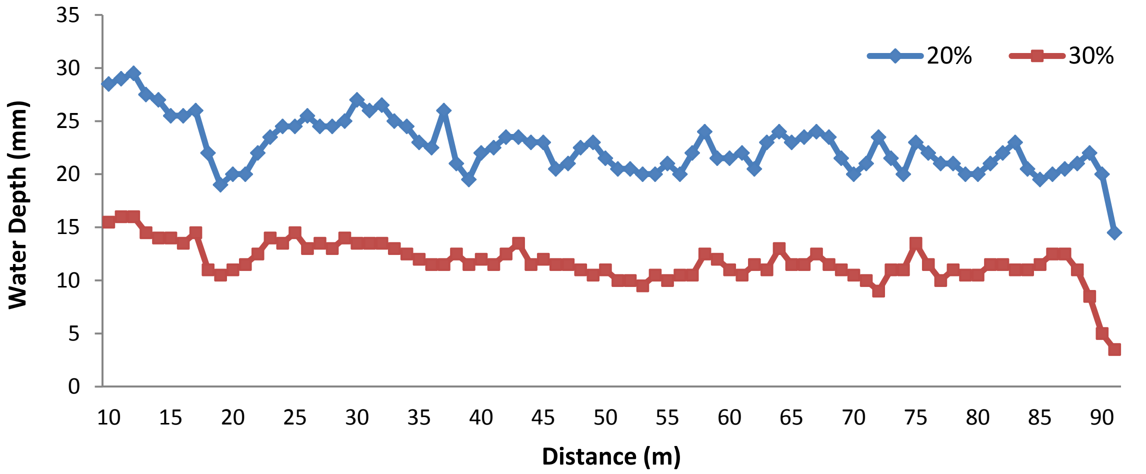

Fig. (4): Water distribution along center pivot with red plates (Test 3)

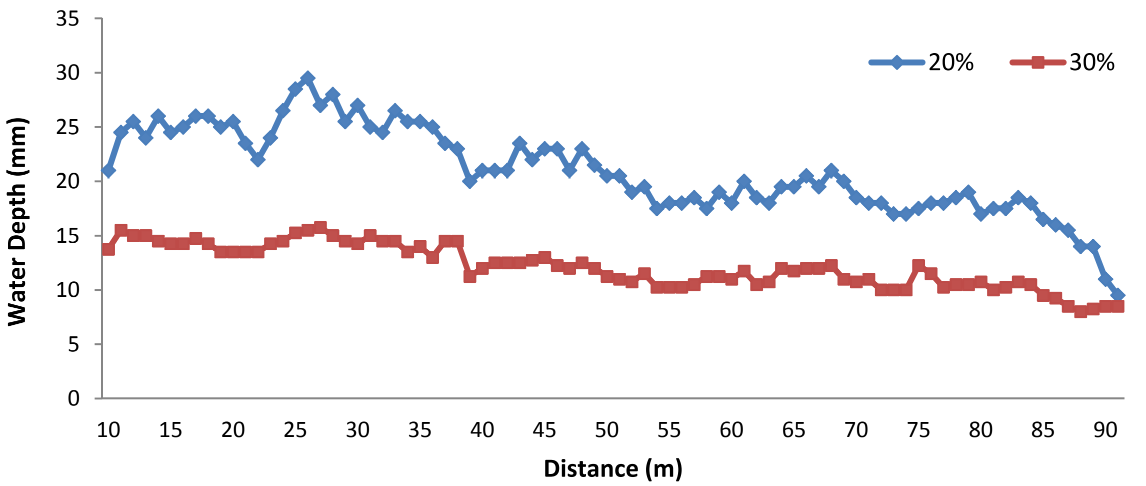

Fig. (5): Water distribution along center pivot with red plates (Test 4)

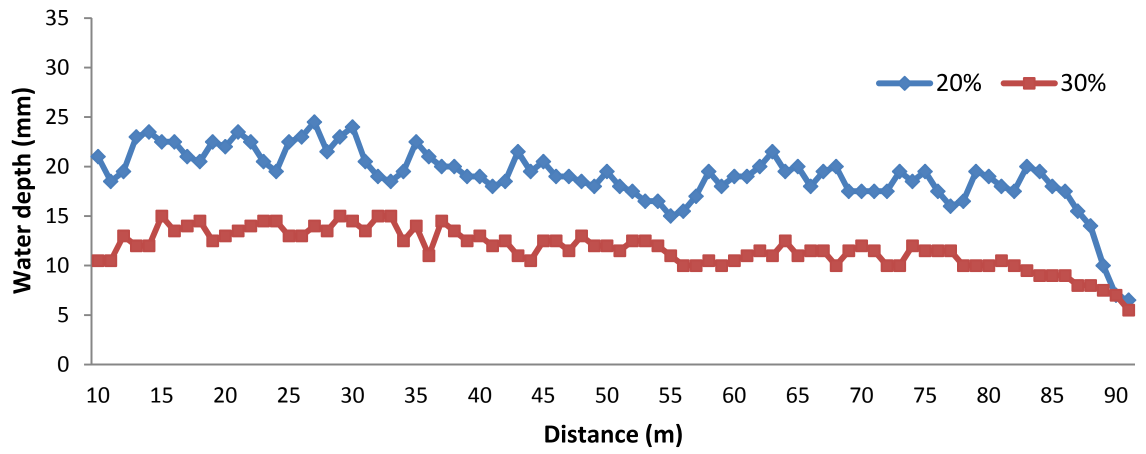

Fig. (6): Water distribution along center pivot with green plates (Test 5)

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9. ACKNOWLEDGMENTS

The author wishes to extend his deep thanks and sincere appreciation to and Prof. Dr. Klaus D. Vorlop, and the irrigation group team at Institute of Agricultural Technology, TI, Braunschweig, Germany for his invitation and scientific help during the staying in Germany. At the same time, the author would like to express his sincere thanks to the Egyptian Government though both Academy of Scientific Research and Technology in Egypt and Benha University for their nomination and financial support.

Signatures

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