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EVALUATION CENTER PIVOT SYSTEMS USING NEW AND OLD SPRAYS AND PRESSURE REGULATORS

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1 ABSTRACT

The objectives of this study were to appraise the performance characteristics for two center pivot irrigation systems (1 and 2) installed on identical areas with different hydraulic conditions: new and old pressure regulators and sprays and the wear out of the equipments. The experiment was been conducted in the Madeira Farm, Silvânia, GO.

The Christiansen Uniformity Coefficient (CUC) was been used for the evaluation of the efficiency of systems. The values gotten for the CUC showed that there was an increase in 24.22% and 9.2% after changing old for the new kits and the water depths were 9.20 and 25.02% lower before changing the kits, for pivots 1 and 2, respectively.

KEYWORDS: center pivot irrigation, distribution uniformity, old and new pressure regulators and sprays.

KLAR, A.E.,SANTANA, R.C., , DUROHA, C. AVALIAÇÃO DE SISTEMAS DE IRRIGAÇÃO POR PIVÔ CENTRAL USANDO DIFUSORES E REGULADORES DE PRECISÃO USADOS E NOVOS

2 RESUMO

Os objetivos deste trabalho foram: 1. avaliar as características de desempenho de dois equipamentos de irrigação por pivô central (pivôs 1 e 2), com áreas idênticas, mas em condições hidráulicas diferentes, com reguladores de pressão e difusores novos e usados; 2. através de comparações, quantificar o desgaste do equipamento em condições de campo.

Para a avaliação do desempenho dos sistemas, utilizou-se o coeficiente de uniformidade de Christiansen (CUC). Os ensaios foram realizados na Fazenda da Madeira, no município de Silvânia - GO. Os valores encontrados para os coeficientes de uniformidade demonstraram que após a troca dos kits de difusores e de reguladores de pressão, os CUC's aumentaram em 24,22 % e 34,76 % e as lâminas aplicadas, com os kits usados, foram inferiores ao kits novos em 9,2 % e 25,06%, nos pivôs 1 e 2 respectivamente.

UNITERMOS: irrigação por pivô central, uniformidade de distribuição, reguladores de pressão e difusores novos e usados.

3 INTRODUCTION

The irrigation method has several systems, since the simplest until the most complex, as the mechanized ones. The introduction of automation into irrigation systems has increased application efficiencies and drastically reduced labor requirements. Several types of mobile machines are available. Nowadays, the most used around the world is the Center-Pivot Sprinkler System which consist of a single lateral, with rotated sprinklers por sprayers, supported by an under truss system and towers on wheels and anchored at the inlet to a swivel joint on a vertical water-supply pipe structure. The lateral rotates continuously about the swivel joint at a pre-set speed, wetting a large area. The Center-Pivot systems are not recommended for irrigating heavy soils with low intake rates, but the method has proved highly successful on some light and shallow soils and in growing crops such as vegetables, potatoes, corn, sorghum sugar beet, wheat, etc. This is largely attributed to the light, frequent applications that continuously provide favorable soil-moisture conditions for the plants (Benami & Offen, 1984).

Irrigation systems has 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 pressure regulators and the sprinklers and sprays must be changed when they are out of order or lost the efficiency. This is main objective of this study: to compare old and new pressure regulators and sprays of two center pivot systems installed six years ago.

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4 MATERIAL AND METHODS

The study was carried out at Madeira Farm, Silvânia GO, where there are two Center Pivot systems with the same area (46.5 ha) Valmatic, Model 4865-PA-VSN/7-1025, low-pressure, seven towers, pipe with 384.90 m long, 24.5 m end gun radius, 2.70 m pipe height at drive unit. The sprays and the pressure regulators were 6 years old. The same pumping unit (195 HP – diesel) is used for both Center-Pivots, the number 1 is 540 m and the number 2, 900 m from the unit. Each tower is moved by electric pump.

After the first distribution uniformity test, the new ones (manufactured by Nelson) changed the old kits (Senninger). After changing, new evaluation were made with the same discharge of the initial design: Pivot 1 = 232 m^3/h and the Pivot 2 = 186.6 m^3/h. All the field tests were conducted under no-wind or light wind conditions. After tests, it was possible to infer that the equipment had a power higher than the pumping needs. In the second stage, the discharges were changed: the Pivot 1, from 232 to 234 m^3/h and the Pivot 2, from 186.6 to 220 m^3/h.

The rotation speed was determined with 10%, 25%, 50%, 75 and 100%. This speed was measured on 20 m of the course of the last tower from the center. The hydraulic characterization of the system was done with the pressure head in the pump, the pressure in and in the final and in the center of the pipe, the of width of the wet spacing on the last interval between two towers and the applied water.

The pumping unit was evaluated through the pressure when the register was shut-off for knowing its mechanical conditions in comparison to the initial project. The pressure on the center and on final of the pipe was determined with the register opened on the point of the higher acclivity. The diesel consumed was measured after each test.

The water depth was done with the 100% of the last tower speed.

The methodology for the parameters collected followed the ABNT norms (1985).

Two collector lines distant three degrees and 5 m one from another were installed from the center to the end of the pipe.

The Christiansen Uniformity Coefficient (CUC) was used (Davis, 1966; Klar, 1991).

5 RESULTS AND DISCUSSION

The Table 1 shows the results of pipe pressure head in the center and in the highest and the most critical point of the area for the old and new sprays and pressure regulators for the Pivot 1. The Table 2 shows the same data for the Pivot 2. In both situations a comparison was done between these data and the ones from the original design.

Table 1 – Data of pressure head evaluation (m) in the Pivot 1

Pressure head	Old pressure regulators and sprays	New pressure regulators and sprays	Data from the original design
Pump	97,50	97,00	86,01
Center of pivot	37,50	47,00	42,67
End of pipe	7,50	20,00	20,00

Table 2 - Data of pressure head evaluation (m) in the Pivot 2

Pressure head	Old pressure regulators and sprays	New pressure regulators and sprays	Data from the original design
Pump	100,00	110.00	103.03
Center of pivot	47.50	52.00	52.57
End of pipe	12.50	20.00	20.00

The data from Pivot 1 showed that the deviation was –11.8% in the pump between the original design and the old kit and 11.34%, when comparing the old and the new ones. At the center of pipe of Pivot 1, the deviation between the data of the project and the old kit was 9.47% and between the old and the new ones, 6.5%. At the end of pipe, the deviation between the original design in relation to the obtained in the field was 62.5%.

In the Pivot 2, the pressure head in the pump showed a 3.30 and 6.10% deviation for the old and the new kits in relation to the original design, respectively; and between the old and the new kits the deviation was 9.09%. Considering the pressure heads in the center of the pipe, the old kit deviated 0.97% in relation to the original design and the new one, 3.78%; the difference before and after the kit changes showed a deviation of 2.38% between the old and the new ones; and at the end of Pivot, this difference was 37.5%. therefore, the Pivot 2 was operating with a pressure head 37.5% less than its need, showing the bad situation of the equipment.

The criteria for the pumping unit installation conditions, according to Silvester (1979) establishes that the relation between available and the required NPSH have to be 1.15 or more. This relationship in this study was 1.92, therefore, fulfilling this condition.

The rotation time is important because it is used on the determination of depth applied and the Tables 3 and 4 show the calculated values from the speed of the last tower.

Table 3 - Speed selections of the last tower measured in the field and in the original design for the Pivot 1

Speed control (%)	Run (m)	Rotation time (h)	
		Measured	Original Design
100	2418,46	8,07	10.52
75	2418,46	10,81	10.00
50	2418,46	16,24	10.00
25	2418,46	32,47	10.00

Table 4 – Speed selections of the last tower measured in the field and in the original design for the Pivot 2

Speed control (%)	Run (m)	Rotation time (h)	
		Measured	Original Design
100	2418,46	8,07	9,02
75	2418,46	10,81	12,02
50	2418,46	16,24	18,04
25	2418,46	32,47	36,08

As it can observe, both Pivots showed that time required to complete one rotation was always inferior than that designed originally, with deviations from 10.00 to 12.20%. This factor depends on the discharge, the rotation time, the irrigated area and the distribution uniformity of the equipment.

The water applied were variations according to the Table 5. In the Pivot 1, where the discharges between the old and the new kits varied only 1%, the water depth of the old one was 12.64% less than the original design and 9.20% than the new one, which was 3.77% inferior than the water depth of the original design, because the run speed was inferior than the one from the original design (Table 6).

Table 5 – Water depth means from the old, new and the original design.

	Water depth mean (mm)		
	Original design	Old kit	New kit
Pivot 1	4,51	3,94	4,34
Pivot 2	3,61	2,96	3,95

Table 6 – Deviation of the water depth means of old, new and the original design for Pivots 1 and 2.

	Original design x old kit	Original design x new kit	Old kit x new kit
Pivot 1	-12,64 %	-3,77 %	9,20 %
Pivot 2	-18,00 %	9,42 %	25,60 %

In the Pivot 2, a 9.42% water depth increase of the new kit in relation to the original design due to discharge increase from 186 m^3 /h to 220 m^3/h. The old kit had a 9.20 and 25.60% waste in relation to the new one, when it use for comparison the water depth (Table 6). Therefore, including the Pivot 1, where there were not significant discharge increase, the equipment waste showed water reduction. In systems where the equipment has the discharge overdimensioned and old kits , the results were worse as in the Pivot 2.

Saad et al. (1987), with seven center-pivots, reached differences from 5 to 15% between the water depth applied and the original design calculation, which show that the results from Pivot 1 were lower than the smallest deviation and those from Pivot 2 were higher than the data related for those authors.

The Table 7 shows the CUC obtained from the evaluation before and after the pressure regulators and sprays with 100% speed control.

Table 7 - Christiansen Uniformity Coefficient (CUC) obtained from the highest point of pipe end for both Pivots with 100% speed control.

	Old kit	New kit	Deviation
Pivot 1	58,42 %	89,49%	34,76%
Pivot 2	66,50%	87,76%	24,22%

The results obtained showed that significant variations in the CUC, being higher in the Pivot 1 (34.76%), which had higher discharge than the Pivot 2. Both equipments had large wastes and, consequently, the uniformity gains were very significant, mainly in relation to the economy of water, electricity, labor, etc.

The Figures 1 to 4 show the water distribution along the pipe before and after the regulators and the sprays change.

The analysis of the Fig. 1 and 2 shows the problem of water distribution along the pipe before and after the kit changes. The water depth over the means verified on the first sprays were caused, probably, is due to the pressure regulator problems, because it is in this region that there are the occurrence of the highest pressures. On the other hand, the water depth below the means verified at the end of the pipe, probably were caused by regulator problems. The Fig. 3 and 4 shows the performance of the equipments with new kits. The Water depths were increased as in the Pivot 1 as in Pivot 2. The new kit correctly working there were a better water distribution along the pipe with higher CUC em 34.76 and 24.22% in the Pivots 1 and 2 respectively (Table 7).

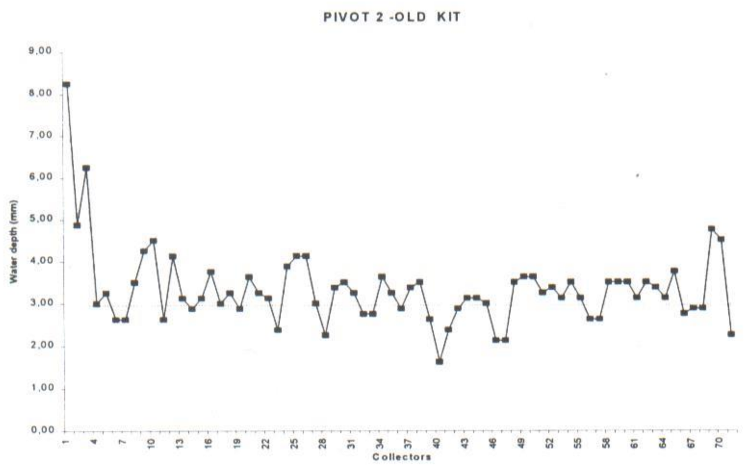

Fig. 1- Evaluation of the Pivot 1, in acclivity position with old pressure regulators and sprays.

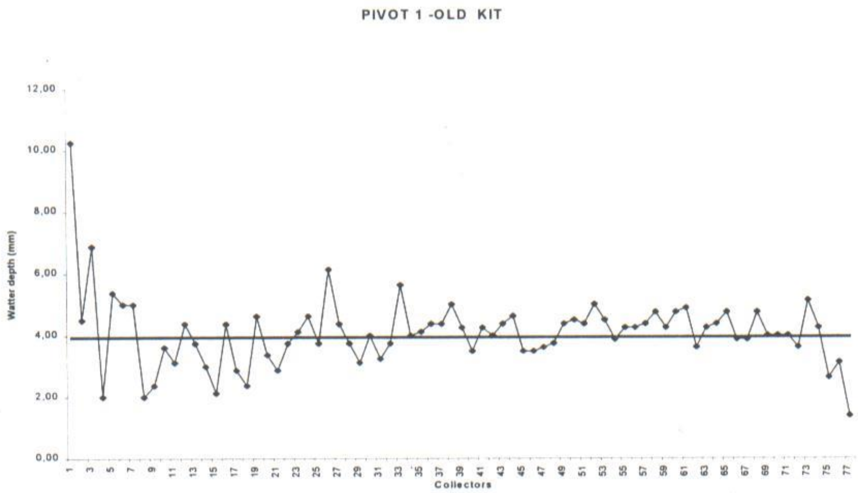

Fig. 2- Evaluation of the Pivot 2, in acclivitous position with old pressure regulators and sprays.

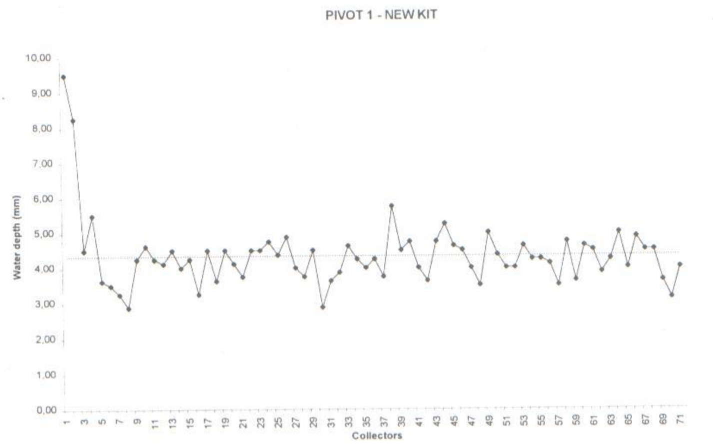

Fig. 3. Evaluation of water depth distribution with new sprays and regulators for pivot 1.

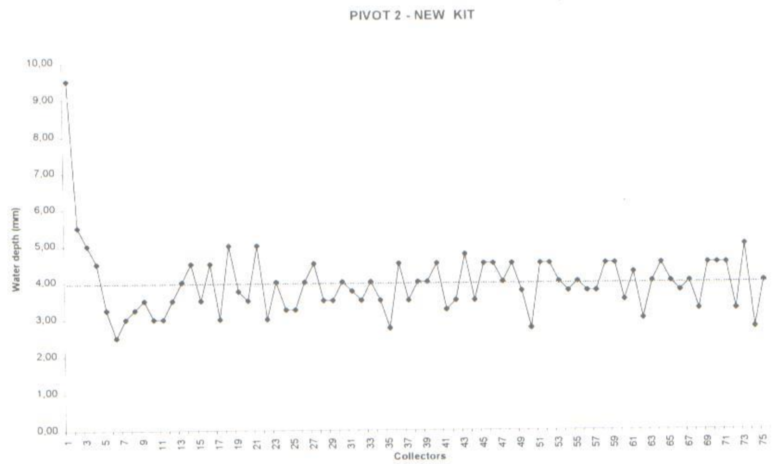

Fig. 4. Evaluation of water depth distribution for Pivot 2 with new pressure regulators and sprays.

6 CONCLUSIONS

1. The higher discharges values used in the new calculations showed that the equipment was underdimensioned.
2. The large waste of the equipment sowed that all system must be evaluated every one or two years.

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