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Evaluation of central pivot irrigation system under different soil and climatic conditions

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Abstract
The centre pivot irrigation system is increasingly becoming popular among farmers around the world on account of the benefits the system can offer compared to other methods. Due to the low irrigation efficiencies and high water losses of surface irrigation and rise of water management and operation costs, the general trend in most of the country is to adopt modern pressurized irrigation systems. Subsequently, large numbers of center pivot systems have been introduced. The efficiency of a center pivot is solely dependent upon the operating parameters and the hydraulic design of the system. Uniformity coefficient from center pivot irrigation should exceed 90%. Recent developments in the center pivot industry have led to contractual relationships between after-market suppliers and irrigation system manufacturers that should support further development of site-specific application of water, nutrients and pesticides in the future. This review article highlights installation and evaluation of Central Pivot irrigation system in different type of soil and climatic conditions and gives an insight of their valuable application in increase in water user efficiency.

Keywords: centre pivot system, irrigation, evaluation, water use efficiency

Introduction
Agriculture is central of food security and economic growth in developing countries. However, food production requires substantial amounts of water. Therefore, irrigation water should be adequately applied to crops to avoid water waste. Hence, the efficiency of water use in agriculture needs to increase in a sustainable manner (Noreldin *et al* 2015) [8]. Centre pivot irrigation systems (CPS) are invented about 67 Years ago to enhance agricultural production and crop water productivity. A centre pivot consist a lateral circulating around a fixed pivot point. The lateral is supported above the field by a series of A-frame towers, each tower having two driven wheels at the base. The lateral line is rotated slowly around a pivot point at the centre of the field by electric motors at each tower. Water is discharged under pressure from sprayers or sprinklers mounted on the laterals as is sweeps across the field or suspended by flexible hose over the crops. Evaluation of a system means to assess the system performance for parameters such as irrigation efficiencies, water distribution coefficient and water adequacy at the field site.

Application of centre pivot irrigation system is suitable for many field conditions. Due to great flexibility of this system and possibility to control its operation with high efficiency, it can be used to irrigate most crops and adapted to nearly all irrigable soils and under most climatic conditions. Nutrients
and chemicals can be applied through this system (Fertigation and Chemigation). Also, the system does not require large number of labour for operation compared with other irrigation methods (Li j, 1997) [7].

Fig 1: Contol Panel of Center pivot irrigation system equipped with a backflow prevention valve used to apply irrigation water, at Central State Farm, NSC, Ltd., Sardargarh, Sriganga nagar, Rajasthan India

Evaluation of energy efficiency of a center pivot irrigation system

Brenon *et al* (2018) [5] evaluated the energy efficiency of a center pivot irrigation system operating in a terrain of variable topography. Values of Pumping Energy Efficiency (PEE), Supply Energy Efficiency (SEE), Global Energy Efficiency (GEE) and Specific Energy (Es in kWh m-3) computed at 18 different angular positions of the lateral line were used as energy efficiency indicators. An ultrasonic flow meter, digital pressure transducers and a power quality analyzer were used in order to evaluate hydraulic (total system flow-Q and total dynamic head-TDH) and electrical parameters (active electrical power-AEP) of the center pivot pumping unit that were required for evaluating the selected energy efficiency indictors. Topographic elevations of the water source, the pumping unit and of the center lateral line were also determined. For the center pivot lateral line, it was necessary to determine, at the 18 angular positions considered, the altitude of the track of each center pivot support tower. Results indicated that currently, even after more than 10000h of use, the center pivot system operates with satisfactory energy efficiency, as indicated by an average GEE value equal to 42.5%, that is classified as "good". Statistical analysis indicated that the topographic disposition of the center pivot lateral line, as characterized by a uphill or downhill disposition, resulted on different PEE, SEE and GEE values, while the average Es value (0.42 kWh m-3) was not affected by the lateral line disposition.

Identificaton of applicability of centre pivot irrigation system in abroad

In April 2015, to identify application of centre pivot irrigation system in Northern State (Sudan) and to find out the major problems facing its use under a local conditions of the State and make recommendations to address them, a study was conducted by Asim O E (2018) [4]. The study included 76 centre pivot machines distributed in nine projects in different locations in the State. The required data was collected by questionnaire and field visits to the sites of the case study. Results of the study revealed that there were some problems facing the use of centre pivot irrigation system under the local conditions of the State, which can be solved by providing trained and skilled labour to operate the system in these projects. A centre pivot irrigation system as a modern technology is promising to come into use in Northern State (Sudan).

A corn (Zea mays) crop was grown in Brazil on a sandy soil, in a Savannah climate, and performance of pivot irrigation was evaluated Gava *et al* (2018) [9]. A randomized complete block design with four replicates of three irrigation treatments including a rainfed control treatment (I0), a 100% replacement (I1), and a 200% replacement (I2) of crop evapotranspiration (ETc). The grain yield (GY) and the plant characteristics including plant height (PH), corn cob insertion height (CIH), stem diameter (SD), and 100 grain mass (M100) were measured. The grain yield results were (I2) 9,634 kg ha-1, (I1) 7,680 kg ha-1, and (I0) 4,229 kg ha-1. All of the plant characteristic variables had higher values for irrigated treatments than for the rainfed treatment. For all except M100, the I2 treatment increased plant characteristic values the most. The I1 just treatment had the highest values for M100. The sandy soil has good drainage and a high soil infiltration rate, so the higher irrigation depth for I2 did not cause water logging and poor aeration in the soil. Maintaining a higher moisture content increased grain yield, but a cost-benefit analysis is needed to assess cost effectiveness from applying more water.

Effect of various working speed of centre pivot sprinkler irrigation system

A centre pivot sprinkler irrigation system was carried out during the maize crop growing season and when operating with different working speeds: S1-40%, S2-60% and S3-80%. For this goal, four uniformity measurements are to be considered in the evaluation; coefficient of uniformity (CU), distribution uniformity (DU), potential efficiency of low quarter application (PELQ) and actual efficiency of low quarter application (AELQ) (Abedinpour, 2017) [1]. The first step of evaluation of the sprinkler irrigation system is to compare the measured uniformity values with the standard values, DU $\geq$ 75%, CU $\geq$ 85%, AELQ and PELQ $\geq$ 90%. Effect of variation of speed produced CU values of 80.3, 82.7 and 86% for S1, S2, and S3 speed, respectively. Furthermore, DU standard value was obtained at S3 speed of 82%. Moreover, AELQ and PELQ were below the acceptable standard level of 90% for all speeds. Non-uniform water application leads to over or under irrigation in various parts of the field which can result in wasted water and energy. Therefore, regular evaluation of the irrigation equipments is needed to efficiently and effectively manage irrigation.

Ahmad *et al* (2017) [3] showed that by using high efficiency irrigation system like centre pivot way of irrigation for seed multiplication activities is much improved as compared to other irrigation ways. Improved crop yield with highquality water use effectiveness under centre pivot irrigation scheme due to its features of high efficiency has been discovered. The water resources of Pakistan are under immense stress due to increased agricultural expansion, population sgrowth and associated urbanization and industrialization. The gap between water demand and supply is growing rapidly. Based on the current population growth rate, the shortage of water in country will increase to 50% in 2025. To overcome this shortage of water, adoption of efficient water saving techniques in agriculture is needed to fulfil the future food security of the country. Under this scenario, a high efficiency irrigation system was developed on 50 acres area with the objectives to produce good quality seed, provide control irrigation and fertigation from this irrigated area and to provide a span for researchers for their research and seed increase activities. This proposed system will minimize application losses to about 10 to 20%, efficient and optimal application of fertigation; its flushing/washing effect keeps the crop clean for enhanced photosynthesis, uninterrupted machinery movement and saves labour cost. This study shows the result of four seasons which includes kharif 2011, Rabi 2011 to 2012, Kharif 2012 and Rabi 2012 to 2013.

Evaluation of the comparative efficiency of three low pressure central pivot sprinkler irrigation systems for their water distribution, uniformity and tendency to recommend changes in system maintenance or repair was carried out by Islam *et al* (2017) [6]. The main objective of this study was to evaluate existing central pivot sprinkler irrigation systems under field conditions at different locations in the country. The study was carried out to evaluate water distribution under central pivot irrigation systems at three locations; National Agricultural Research Center (NARC), Islamabad, Arid Zone Research Institute, Bahawalpur (AZRI, BWP) and Thana Boula Khan (TBK, Sindh) in Pakistan. Water distribution coefficients used in the evaluation were: Christiansen's coefficient of uniformity (CU %), distribution uniformity (DU %) and

scheduling coefficient (Sc %). The results showed that overall mean values for the coefficient of uniformity ranged from 87 to 92%, distribution uniformity ranged from 90 to 93% and scheduling coefficient ranged from 1.07 to 1.12. The results showed that overall mean value of Christiansen Coefficient of Uniformity (CU) was 87%, 91% and 92% and Distribution Uniformity (DU) was 93%, 92% and 90% of NARC, BWP and TBK locations, respectively. According to review the DU and CU for all center pivot sprinkler systems should be in the range of 85% or greater and 90-95%, respectively, for excellent ratings. Scheduling coefficient of NARC, BWP and TBK locations were obtained 1.09, 1.07 and 1.12, respectively.

Centre pivots are performing well although potential system performance and sugarcane yields are constrained by limited water and power supply, pressure variations, clogging of sprinklers, rutting of un-gravelled tracks, soil compaction, low water holding capacities, reduced infiltration rates and game encroaching sugarcane. It is therefore recommended that constant system checks, improvement of traction on centre pivot wheels, development of new model for water and power budgets as well as undertaking of extensive research on the effects of mechanical harvesting be done so as to improve centre pivot irrigation system performance and sugarcane yields at Ubombo Sugar Estate.

The Research Centre at which Centre Pivot Irrigation System (CPIS) is installed and the whole study is carried out has 464 ha (1146 acres) land area for research in various aspects of agriculture. The 105.8 ha area is irrigated while the remaining 358.2 ha area is rained. Irrigated area is further divided into 43.8 ha referred as main precisely block which has an underground pipe network connected to a water reservoir filled by Rawal Dam water. Irrigation water is applied to this précised block by gravity flow from the reservoir. The remaining 62 ha irrigated area is irrigated through open water channels. Rawal Dam is the main source of irrigated area. In addition to that water three tubewells are operative for providing supplementary irrigation if needed. In general, this research centre does face a water scarcity for crop production which needs an earlier solution (Ahmed, 2013) [2].

Conclusion

The advantage of centre pivot irrigation system is to operate under different speeds with acceptable water distribution uniformities. It is one of modern irrigation systems is promising to be widely used and deployed in all over the world. The system should be reliable and fast-fixable in field. Encouraging investors in agricultural sector to use this system. Importance of evaluating performance of centre pivot system (water application efficiency and uniformity of water distribution) by specialists to address shortcomings of irrigation network in a timely manner and identify problems arising from design or operation. Evaluation must be done periodically to address problems in a timely manner.

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