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PERFORMANCE EVALUATION OF SPRINKLERS (MINI AND MICRO) UNDER USING TREATED WASTE WATER FOR LANDSCAPE

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ABSTRACT: The purpose of this study was to assess the performance of two sprinkler types,mini and micro, type order to identify the best operating circumstances for achieving high application efficiency. The application efficiency of low quarter (AELQ), distribution uniformity (DU), and coefficient of uniformity (CU) were assessed at varying operating pressure (100, 150, and 200 kPa) and riser height (30, 50, and 80 cm). In order to prevent water loss and reduce the cost of the irrigation system, it was determined that the operating conditions that produced the highest coefficient of uniformity, distribution uniformity, and application efficiency of the low quarter were an operating pressure of 150 kPa and riser heights of 80 cm for mini sprinklers and 50 cm for micro sprinklers. When using treated waste water in a landscape irrigation system, the distribution uniformity values for micro sprinklers are higher than those for mini sprinklers under the same operating pressure and riser height conditions.

Key words: Treated wastewater; performance evaluation; sprinklers; uniformity; landscape..

INTRODCTION

Water must be maintained and used wisely since it is a scarce and valuable resource that is necessary for agricultural output. Subsurface irrigation, sprinklers, and microirrigation are all relatively new systems with a lot of benefits. Because of its great control over water distribution and compatibility with the majority of soil and crop types, sprinkler irrigation is a relatively new technique in Egypt, particularly in the recently reclaimed lands. Additionally, according to **El-Ansary*et al.* (2003),** sprinkler irrigation disperses water more evenly than any other technique. Increased usage in various of purposes, including drinking, industry, navigation, and agriculture, is the cause of water scarcity and shortages. It is necessary to rationalize the water consumption. Only better water management and the use of contemporary irrigation methods in agriculture will make this possible.

According to a study, Egypt's water resources were estimated to be 76.6 billion cubic meters in 2017. This amount was split between 55.5 billion cubic meters of water from the Nile River, 1.3 billion cubic meters of rain, 4 billion cubic meters of water that was returned to the Nile, 7.4 billion cubic meters of water that was reused from agricultural wastewater, and 8.4 billion cubic meters of groundwater (**Shehata, 2020**).

Finding contemporary solutions to rationalize water use and manage the problem of water shortages, which is causing anxiety in many nations, is the primary responsibility of irrigation engineers and agricultural scientists. Of the 17 billion cubic meters (BCM) of agricultural drainage water (ADW) produced in Egypt each year, 55% is used for irrigation. However, untreated wastewater contaminates a large number of drainage canals, leading to variations in ADW quality. Determining if ADW is suitable for irrigation is the main

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obstacle to its reuse. Landscape plants are thought to be able to withstand the weather, according to research on the usage of treated water. The element most likely to cause issues for landscape plants is chlorine (CI) in wastewater. However, only extremely sensitive plant species are expected to have substantial adverse impacts (**Wu *et al.*, 1995**).

Total dissolved solids (TDS) levels in the water at Rosetta Branch varied between 375 and 480 mg/l during low flow and between 280 and 300 mg/l during high flow, according to **El-Bouraie*et al.*, (2010).** These TDS levels fall within the 500 mg/l regulatory limit established by Law 48/1982. Cd, Cr, Cu, Fe, Mn, Pb, and Zn levels, however, were below the limits set by Law 48/1982. These results indicate that the water in Rosetta Branch is highly contaminated with organic loads because of low dissolved oxygen concentrations (DO) and high COD values. Numerous outfalls discharge into the Branch, resulting in significant loads of organic and inorganic pollution in the waters, according to multiple studies. Total dissolved solids (TDS) levels in the water at Rosetta Branch varied between 375 and 480 mg/l during low flow and between 280 and 300 mg/l during high flow, according to **El-Bouraie*et al.* (2010**). These TDS levels fall within the 500 mg/l regulatory limit established by Law 48/1982. Cd, Cr, Cu, Fe, Mn, Pb, and Zn levels, however, were below the limits set by Law 48/1982. These results indicate that the water in Rosetta Branch is highly contaminated with organic loads because of low dissolved oxygen concentrations (DO) and high COD values. Numerous outfalls discharge into the Branch, resulting in significant loads of organic and inorganic pollution in the waters, according to multiple studies.

According to **Abdel-Dayem (2011**), the surface water of Lake Nasser has dissolved oxygen concentrations (DO) between 7.5 and 9.9 mg/l, which are higher than the legal standard of 5 mg/l; total dissolved solids (TDS) concentrations between 124 and 168 mg/l, which are within the legal permitted range (500 mg/l); and power of hydrogen (PH) values in the range 7.58.3, which are within the law's permissible range (7.0-8.5). Furthermore, the average chemical oxygen demand (COD) values were between 8.0 and 14.0 mg/l, and they were higher at high flow (7–24 mg/l) than at low flow (8–11 mg/l). As a result, while the COD levels at low flow were in compliance with legislation 48/1982 (10 mg/l), those at high flow did not.

Egypt is facing a severe wastewater crisis, according to **Abdelrazek (2019**), which is primarily causing the Nile River's water quality to decline. As a result, the Egyptian government was able to enact several laws to stop the water in the Nile from becoming contaminated. A sprinkler irrigation system's water application efficiency is influenced by a number of factors, including variations in the discharge of individual sprinklers along the lateral lines, variations in the distribution of water within the sprinkler spacing area, and water loss from direct evaporation from the spray and evaporation from the soil surface prior to the water being utilized by the plants. Additionally, operating pressure and riser height have an impact on sprinkler performance (**Keller and Bliesner, 1990)**. Under field operating conditions, the spray losses from three low-pressure center pivot sprinkler irrigation systems. Three distinct spray-nozzle heights from the ground surface were used to measure the evaporation losses during sprinkling. For heights of 1.25, 1.75, and 2.5 meters, the corresponding average values were 15.63, 21.19, and 35.77% (**Abo-Ghobar, 2003**). A perfect irrigation system should administer water evenly and reduce losses (**Haman *et al*, 2003**). For all kinds of micro-sprinklers, the diameter of the throw and the discharge both increase as the pressure rises (**Muley, 2004, Kale, 2006)**. The application efficiency of low quarter (AELQ) values under low-pressure center pivot sprinkler irrigation systems varied from 75.70% to 52.70% when the operating pressure was raised from 220 to 275 kPa (**Ismail, 1995**).

The consistency of the use of various irrigation techniques in the sugar business across South Africa's five sugar-growing areas. Center pivot, dragline, micro-irrigation, floppy, and semi-permanent sprinkler systems had average low-quarter distribution uniformity (DU) of 81.40%, 60.90%, 72.70%, 67.40%, and 56.90%, respectively (**Ascough and Kiker, 2002**). The consistency of a linear motion irrigation system and a central pivot along their entire length.

They discovered that the center pivot and the linear move irrigation system had averaged low quarter distribution uniformity values of 90.0% and 74.0%, respectively (**Dukes and Perry, 2006**). Examined two varieties of sprinkler systems: center pivot and soiled-set. They demonstrated that the average value of (CU) for the soiled-set system was 84.59% when the working pressure increased from 210 to 480 kPa, and the (CU) values for the center pivot system dropped from 87.16% to 84.25% when the operating pressure increased from 55 to 375 kPa (**Tarjuelo*et al.*, 1999**). Under the same operating pressure of 150 kPa and nozzle size of 3.5 x 2.4 mm, the coefficient of uniformity (CU) values for Rain Bird sprinkler and developed sprinkler dropped from 78.50% to 72.0% and 84.60% to 65.0%, respectively, when the riser height was increased from 50 to 150 cm (**El-Sherbeni, 1994**).

Evaluated the field distribution of 27 subsurface drip (SSD) systems and seven floppy sprinklers. They discovered that for the (SSD) system, the coefficients of uniformity ranged from 53.0% to 98.0%, while for the floppy sprinkler, they ranged from 66.0% to 84.0%. According to **Griffiths and Lecler (2001**), the distribution uniformities of floppy sprinklers ranged from 59.0% to 78.0%, while those of the SSD system ranged from 33.0% to 94.0%. Excellent (75–85%), good (65–75%), and bad (50–65%) are the suggested (DU) values. Multi-stream, single-stream, and fixed-spray sprinklers had the highest, lowest, and intermediate values, respectively (**ITRC, 1991 and Schwankl*et al.*, 2003).**

Tried to attain a suitable irrigation intensity and good water dispersion for a novel sprinkler nozzle known as the floppy sprinkler. For the 8.0 m sprinkler and lateral spacing at 1.5 m sprinkler height and 200 kPa operating pressure, they discovered that the averaged Christiansen coefficient of uniformity (CU) and distribution uniformity (DU) were 88.01 percent and 80.94 percent, respectively (**Aboamera and Sourell, 2003**). At an operating pressure of 250 kPa, the distribution uniformity (DU) values under a fixed sprinkler watering system increased from 69.0% to 94.6% for square patterns, from 53.0% to 83.90% for rectangular patterns, and from 57.0% to 96.70% for triangular patterns (**Badr, 1992**).

High level of regularity in water distribution The ideal distance between spinner sprinklers was determined to be 60% of the throw's diameter in a square arrangement and between 50% and 70% of the throw's diameter in a triangle arrangement. It was suggested that impact sprinklers be spaced 50% from the throw's diameter in square layouts and between 50% and 60% in triangular layouts. Even for the same served area, a triangular configuration produced greater homogeneity than a square one (**Amer,2006**).

The main goal of this study was to evaluate the irrigation performance of mini sprinklers with micro sprinklers that accomplish optimal water distribution since designing an effective sprinkler system requires identifying the ideal operating conditions that achieve high CU, DU, and AELQ.

MATERIALS AND METHODS

The experiment was conducted at landscape area located in Hyde Park Avenue in the Fifth Settlement of New Cairo, during the season 2022 year. The experimental unit is consists of water source, pump with 50 hp, control valve, pressure gauge, flow meter, pressure regulator, riser and sprinklers. Tow devices of sprinkler, mini type and micro type were installed as a permanent system. The mini and micro sprinkler design is suitable for different installation options as required for the crops.

Disc filters A 130-micron disc filter was used to remove impurities from the water. The disc filter consists of stacked rings that trap particles and prevent clogging. This filter type is more efficient and durable than mesh filters, as it can be cleaned without sustaining damage.Geotextiles these synthetic materials, with a permeability of 200 g/m², were used to filter out larger particles from water. Geotextiles were also utilized to enhance the stability of the irrigation system by preventing soil erosion and sediment accumulation in the pipes.Reservoirs and sedimentation basins reservoirs and sedimentation basins were used to conduct sedimentation of heavy elements present in the water, thereby ensuring optimal performance for the irrigation networks.

In order to collect water, plastic catch cans measuring 120 mm in diameter and 40 mm in height were placed beneath sprinklers and across the whole sprinkler circle, inside the spray nozzles' throw range. As shown in Figure 1, the catch cans were distributed in accordance with the (**ASAE Standard, 2001**). Table 1 shows the spacing of collectors (catching cans) for determining the radius of throw. Under Egyptian conditions, the mini and micro sprinklers were tested at varying operating pressure levels (100, 150, and 200 kPa) and riser heights of (30, 50, and 80 cm).A pressure gauge with a pressure pitot tube attached was used to measure the operating pressure. The highest pressure that was recorded was obtained by centering the pressure needle in the jet of 3 mm away from the sprinkler nozzle.

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Table (1): Collector spacing in accordance with ASAE Standard, 2001.

Sprinkler Radius of Throw, m	Maximum Collector Spacing Center to Center, m
0.3 - 3	0.30
3 - 6	0.60
6 - 12	0.75
> 12	1.50

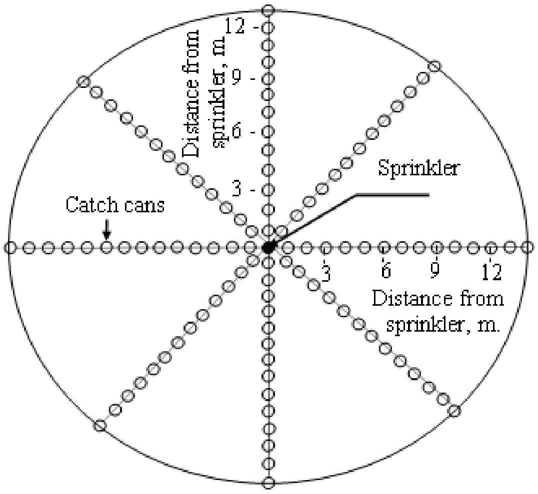

Fig. 1: The distribution of catch cans is shown schematically

By attaching a flexible tube to the sprinkler nozzle and gathering a known volume of water in a container over a predetermined amount of time (2 minutes), the sprinkler's flow rate was determined. The following formula was used to determine the flow rate (**Amer, 2006):-**

$$Q = \frac{V}{t}$$

Where V is the collecting water volume in m^3, t is the water collection duration in h, and Q is the sprinkler flow rate in $m^3\ h^{-1}$.

The following formula was used to determine the distribution uniformity (DU) (**Heermann*et al.*, 1990**):

$$DU = 100 \frac{Z_{lq}}{Z_{av}}$$

Where Z_{lq} is the average catch depth in the field's low quarter (in millimeters), Zav is the average catch depth throughout the field (in millimeters), and DU is the distribution uniformity in percentage.

Several similar collectors were arranged in an equally spaced grid in the field surrounding the sprinkler to test for uniformity. **Christiansen (1942)** used the following formula to determine the coefficient of homogeneity after measuring and recording the amount of water captured in each can:

$$CU = 100 \left(1 - \frac{\Sigma \left| X_i - \bar{X} \right|}{n\ \bar{X}} \right)$$

Where n is the number of measuring collectors, Σ is the sum of n values, $|\ |$is the absolute value, Xi is the amount of each individual collector in mm, $\bar{X}$ is the mean of the collectors' amount in mm, and CU is the Christiansen's coefficient of uniformity in percentage.

The following formula was used to determine the application efficiency of the low quarter (AELQ, %) (**Samir *et al.*, 2012**):

$$AELQ = 100 \frac{Z_{r.lq}}{D}$$

Where D is the average depth of water applied in millimeters and Zr,lq is the average low quarter depth of water collected in millimeters.

RESULTS AND DISCUSSION

Impact of riser height and operating pressure on wetted diameter and discharge for two types of sprinklers

Figures 2 and 3 showed that the impact of operating pressure and riser height on discharge for two different sprinkler types: mini sprinklers and micro sprinklers. It is clear that these factors had a significant impact on each sprinkler's discharge.

Figures 2 and 3 showed that the impact of operating pressures between 100 and 200 kPa and riser heights of 30, 50, and 80 cm on mini sprinkler discharge. It is evident that the discharge rose as the mini sprinkler's operating pressure and riser height increased. By raising the working pressure from 100 to 200 kPa and the riser height from 30 to 80 cm, respectively, the discharge rose from 16 to 39 l/h. For a tiny sprinkler, the lowest discharge was achieved with a riser height of 30 cm and an operating pressure of 100 kPa. Additionally, the tiny sprinkler's maximum discharge was achieved with a riser height of 80 cm and an operating pressure of 200 kPa.

By raising the working pressure from 100 to 200 kPa and the riser height from 30 to 80 cm, respectively, the micro sprinkler's discharge rose from 25 to 35 l/h. For micro sprinklers, the lowest discharge was achieved with a riser height of 30 cm and an operating pressure of 100 kPa. Additionally, the micro sprinkler's maximum discharge was achieved at an operating pressure of 200 kPa and a riser height of 80 cm. The findings showed that the operating pressure and sprinkler riser height had a significant impact on the discharge from mini and micro sprinklers.

The impact of riser height and operating pressure on wetted diameter was displayed in Figures 4 and 5. For mini and micro sprinklers, the wetted diameter was often influenced by both the riser height and operating pressure. The findings showed that compared to other treatments, the wetted diameter of the micro sprinkler with an 80 cm riser height was marginally greater. The small sprinkler's wetted diameter grew from 1.3 m with a 30 cm riser height to 2.2 m with an 80 cm riser height when the operating pressure was raised from 100 to 200 kPa and the riser height was raised from 30 to 80 cm. Additionally, the tiny sprinkler's maximum wetted diameter was achieved with an operating pressure of 200 kPa and a riser height of 80 cm. All tested operating pressures and riser heights under investigation showed comparable patterns.

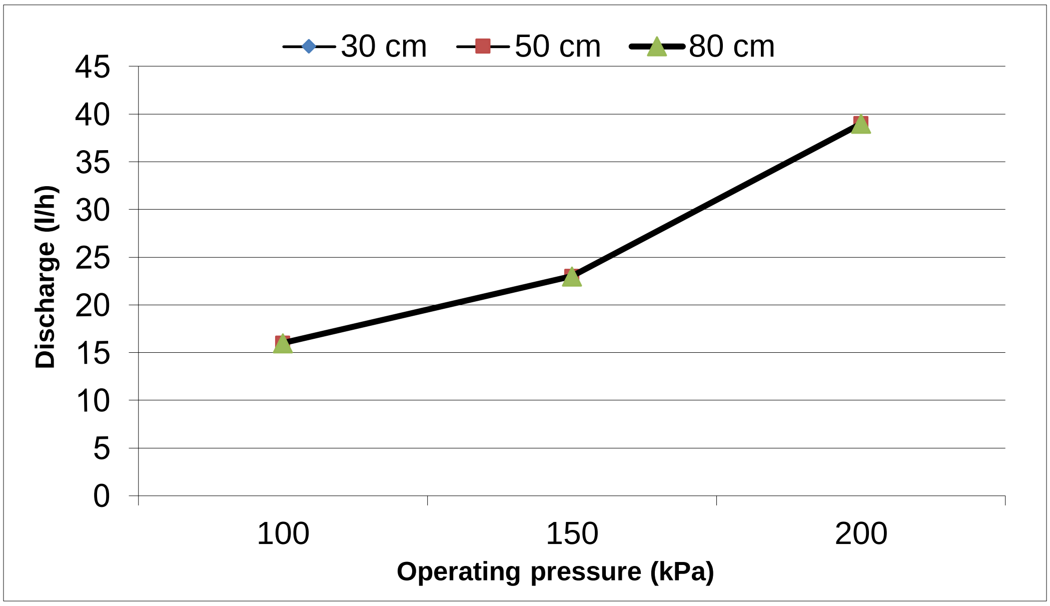

Fig. 2: Effects of riser height and operating pressure on mini sprinkler discharge

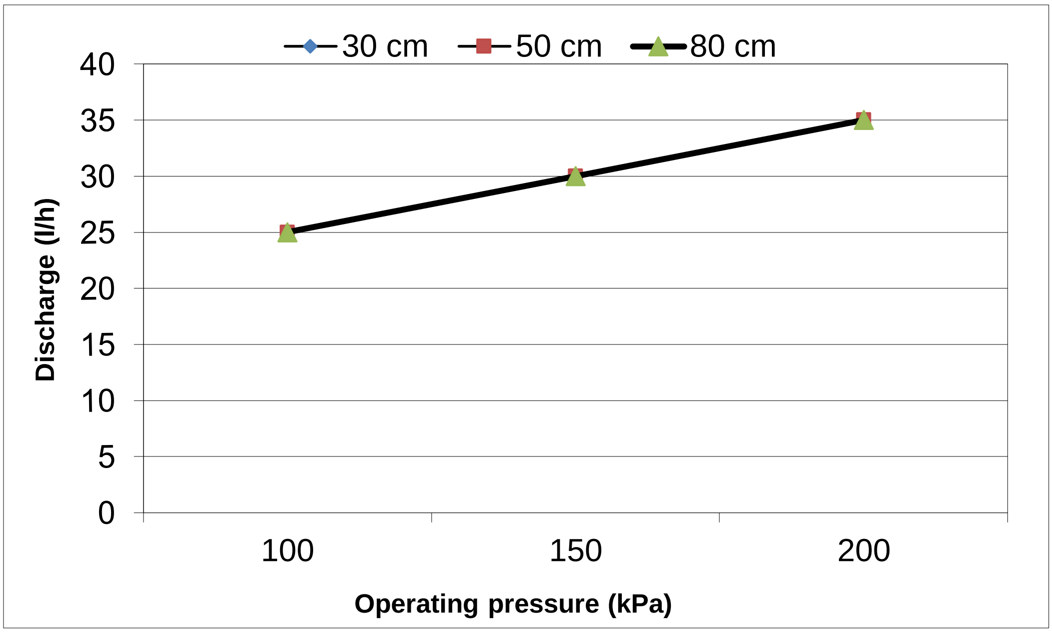

Fig. 3: Effects of riser height and operating pressure on micro sprinkler discharge

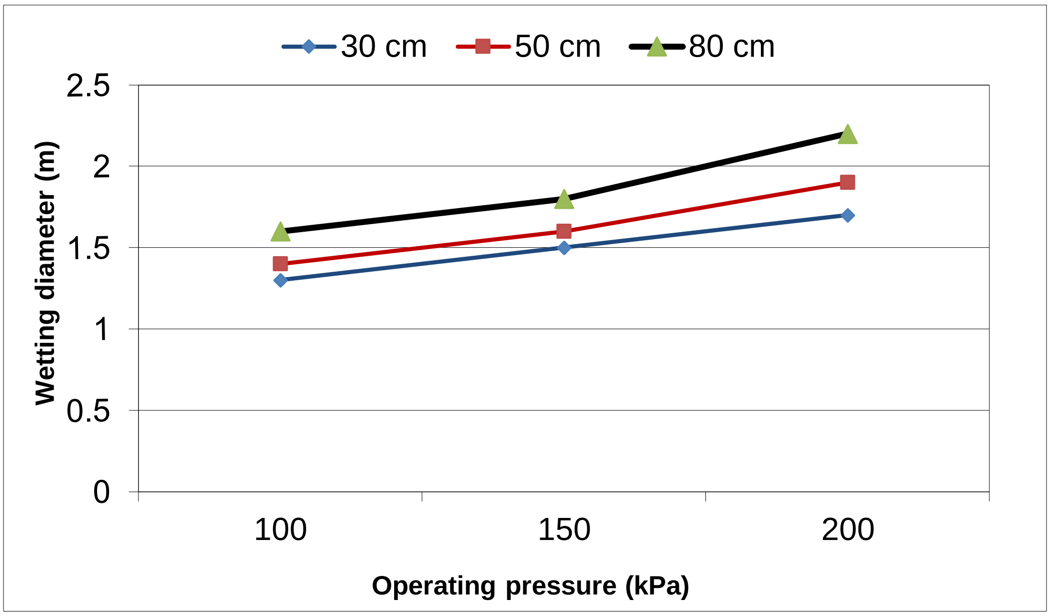

Fig. 4: Effects of riser height and operating pressure on mini sprinkler wetting diameter

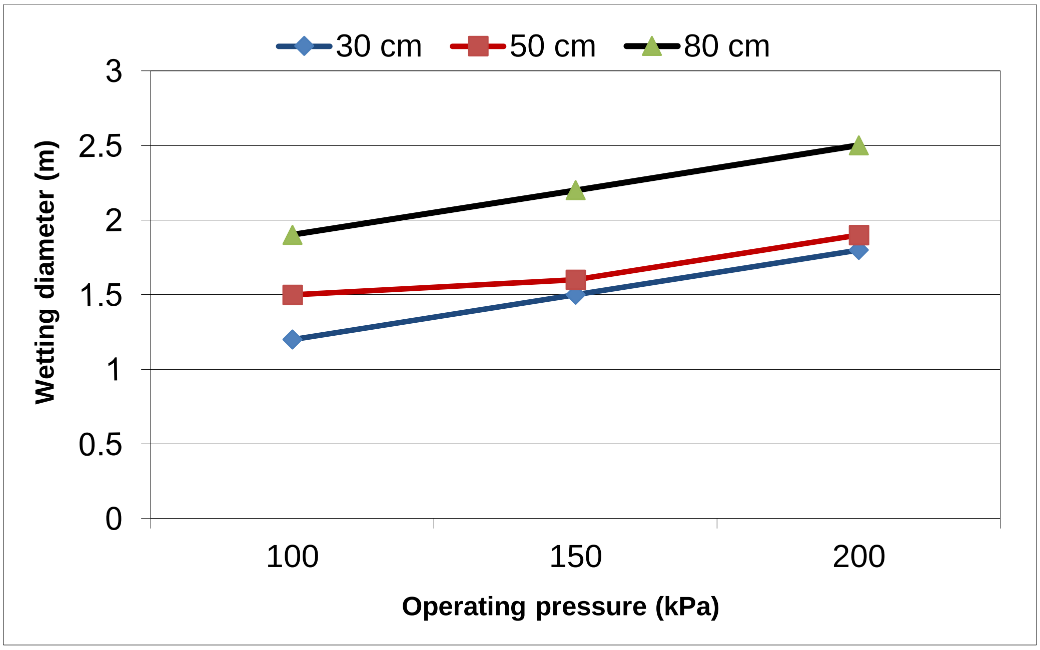

Fig. 5: Effects of riser height and operating pressure on micro sprinkler wetting diameter

However, for the micro sprinkler, the riser height and operating pressure had an impact on the wetted diameter. The findings showed that the micro sprinkler with an 80 cm riser height had a larger wetted diameter than the other treatments. The wetted diameter of the micro sprinkler rose from 1.2 m with a 30 cm riser height to 2.5 m with an 80 cm riser height when the operating pressure was raised from 100 to 200 kPa and the riser height was raised from 30 to 80 cm. Additionally, the micro sprinkler's maximum wetted diameter was achieved with an operating pressure of 200 kPa and a riser height of 80 cm. Under various riser heights, the discharge and wetted diameter grew as the operating pressure increased. According to the results, it is possible to produce high discharge and wetted diameter for mini and micro sprinklers by combining high operating pressure with high riser height. This is consistent with the findings published by **Taha (2008).**.

Uniformity of water application

One of the main concerns in the sprinkler irrigation design process is consistency of application. At various riser height and operating pressure levels, the low quarter's application efficiency, uniformity, and uniformity coefficient were measured. The link between operating pressure, low quarter application efficiency, distribution uniformity, and coefficient of uniformity at various riser height levels was displayed in Figures (6 and 7). Overall, for every evaluated operating pressure and riser height, the DU rose as the working pressure increased. However, at 150 kPa and an 80 cm riser height, the DU was greater than the other treatments, being classed as 83.66% (Good).

The DU value rose from 65.68% to 70.35% but was still categorized as medium when the working pressure was raised from 100 to 200 kPa at a riser height of 50 cm. As the operating pressure rose from 100 to 200 kPa, the DU values dropped, and it was categorized as poor at a riser height of 30 cm. Additionally, when the mini sprinkler's riser height was extended from 30 cm to 80 cm, the values of DU at the same operating pressure increased as well, which is consistent with the findings published by **Taha (2008).**

The DU value for the micro sprinkler increased from 83.43% to 87.58% when the working pressure was raised from 100 to 200 kPa at an 80 cm riser height, but it was still categorized as excellent. At the same time as the working pressure rose from 100 to 200 kPa, the DU values dropped from 86.35% to 85.11% at a riser height of 30 cm, and they were categorized as good. Additionally, when the riser height increased from 30 cm to 80 cm, the DU values at the same operating pressure increased.

The results showed that the highest DU values were obtained at an operating pressure of 150 kPa and a riser height of 80 cm; these values are classified as "Good" for mini sprinklers and "Excellent" for micro sprinklers, in accordance with **Keller and Bliesner (1990)** classification classification.

Additionally, raising the operating pressure from 100 to 200 kPa causes the CU to increase from 60.69% to 65.30% for a riser height of 30 cm that is classified as poor, from 73.28% to 82.30% for a riser height of 50 cm that is classified as good, and from 83.37% to 86.43% for a riser height of 80 cm that is classified as good. In comparison, the small sprinkler's CU dropped from 86.43% to 79.83% as the operating pressure increased from 150 to 200 kPa.

According to the findings, the mini sprinkler's CU was classified as "good" when the operating pressure was 150 kPa and the riser height was 80 cm. The micro sprinkler's CU was classified as "excellent" when the operating pressure was 150 kPa and the riser height was 50 cm. These results are consistent with those published by **Christiansen (1942).**

Additionally, the AELQ rises when the riser height is increased from 30 to 80 cm. It is obvious from the obtained data that the maximum values of AELQ were attained at operating pressure of 150 kPa and riser height of 80 cm it was 75.29% for small sprinkler. These findings for AELQ are consistent with those for DU and CU. This indicates that a small sprinkler with a riser height of 80 cm and an operating pressure of 150 kPa might produce excellent water application uniformity (Good). Additionally, the results showed that the micro sprinkler was categorized as "Good" since the greatest AELQ values were obtained at an operating pressure of 150 kPa and a riser height of 50 cm.

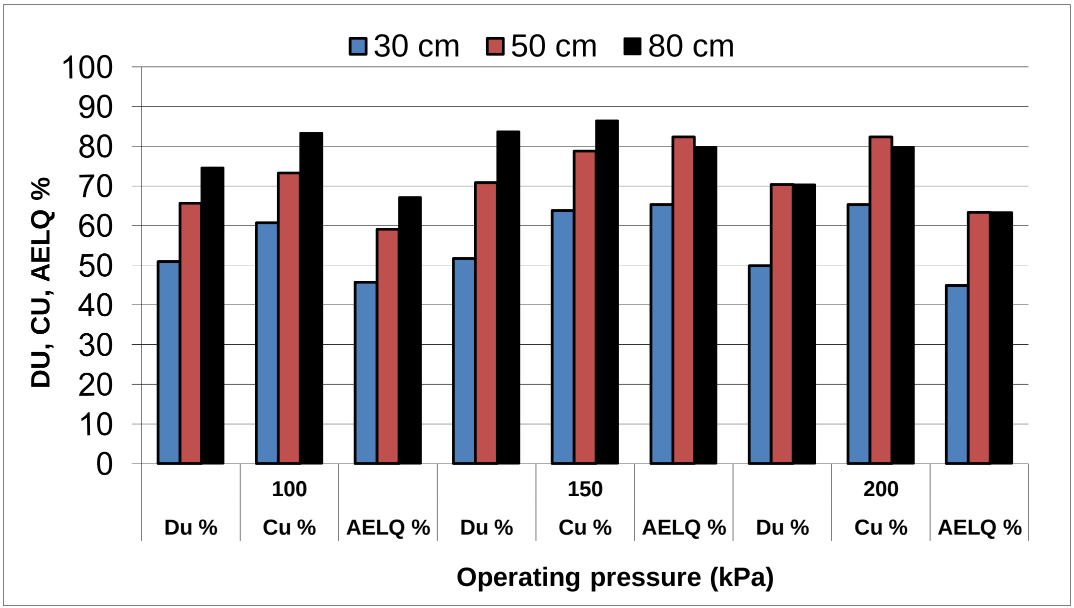

Fig. 6: Relationship between operating pressure and low-quarter application efficiency, distribution uniformity, and coefficient of uniformity for mini sprinkler type at varying riser heights under operating pressures

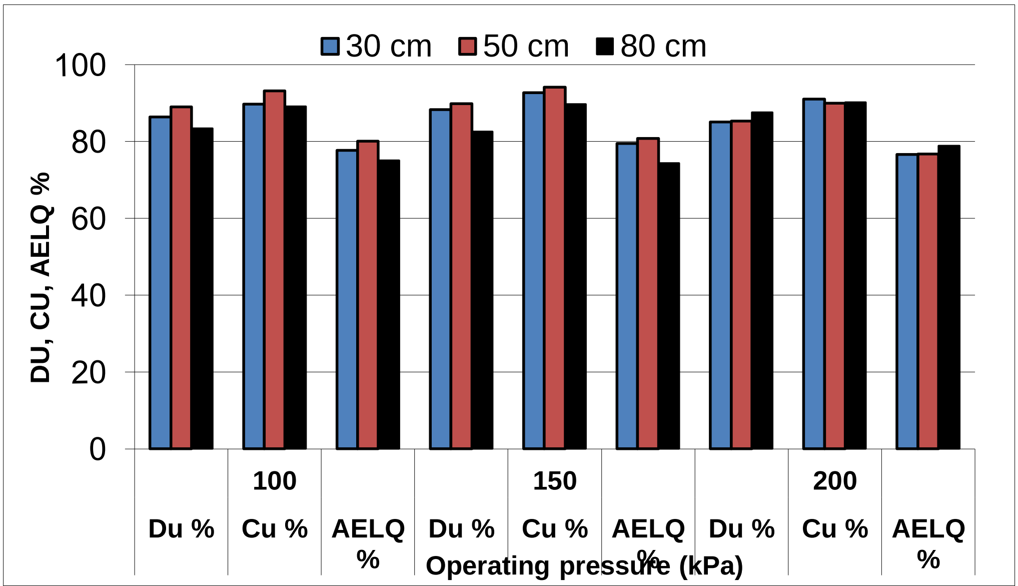

Fig. 7: Relationship between operating pressure and low-quarter application efficiency, distribution uniformity, and coefficient of uniformity for micro sprinkler type at varying riser heights under operating pressures

According to the results obtained, it is evident that there is a parallel trend of DU, CU, and AELQ for both types of sprinklers for all tested operating pressure and riser height levels **(ITRC, 1991; Schwankl*et al*., 2003; Taha, 2012).**

Conclusions

It has been determined that when treated wastewater was used in a landscape irrigation system, the performance of two sprinkler types mini and micro was influenced by the operating pressures and riser heights. The following conclusions were drawn from the data.

1. For both sprinkler types, raising operating pressure resulted in an increase in discharge and wetting diameter; however, this requires more energy.
2. At an operating pressure of 150 kPa and a riser height of 80 cm for mini sprinklers and 50 cm for micro sprinklers, the highest level of water distribution homogeneity was attained.
3. Under the same operating pressure and riser height conditions, the micro sprinkler's distribution uniformity values are higher than the mini sprinkler's.

Based on the data, we deduced that both sprinkler types can operate at high performance levels with an operating pressure of 150 kPa and riser heights of 50 and 80 cm.

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أداءالرشاشات (المينيوالميكرو) تحتاستخدامميا هالصرفالمعالجفيالمسطحاتالخضراء

باسممسعدعتمان-محمـدقدريعبدالوهاب--ياسرصبحعوضالله-

قسمالهندسةالزراعية - كليةالزراعة - جامعةالزقازيق

الهدفالأساسلهذاالبحثتقييمأداءنوعينمنالرشاشاتعندالريبمياةالصرفالمعالجفيالمسطحاتالخضراء. حيثتمإنشاءوحدةإختبارتجريبيهبمنطقةالاندسكيبفيكومبوندهايدباركفيالتجمعالخامس. وتمدراسةإنتظاميةتوزيعالمياهللرشاشالمينيوللرشاشالميكرووتحتتأثيرضغوطتشغيل (100، 150، 200،كباسكال) وارتفاعاترأسالرشاش (30، 50، 80 سم). أظهرتالنتائجأنأعلىقيملمعاملالإنتظاميةالتوزيعCU ،كفاءةإنتظاميةالتوزيع DU،وكفاءةإضافةالمياه AELQ تمالحصولعليهماللرشاشالميكروكانت 94.14% ، 89.81% ، 80.83% والرشاشالميني 86.43% ، 83.66%، 75.29% علىارتفاع 50 سمللرشاشالميكرووعليارتفاع 80 سمللرشاشالمينيوضغطتشغيل 150 كباسكالعلىالتوالي.

ويوصىبتشغيلالرشاشاتعندضغطتشغيل 150 كباسكالللحصولعلىأعلىقيمةلمعاملإنتظاميةاضافةالمياة،كفاءةإنتظاميةالتوزيع،وكفاءةإضافةالمياهوذلكلتقليلفقدالمياهوتكاليفالإنشاءوتقليلتكاليفالنظام..

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