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Effect of Combination Factors Operating Pressure, Nozzle Diameter and Riser Height on Sprinkler Irrigation Uniformity

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Abstract – *The irrigation uniformity of sprinkler irrigation system depends on many design factors such as nozzle type, nozzle diameter, operating pressure and riser height. An experimental study was performed to investigate the effect of combination factors of operating pressure, nozzle diameter and riser height on sprinkler irrigation uniformity. Different operating pressures, nozzle diameters and riser heights have been used. The irrigation uniformity coefficients such as coefficient of uniformity (CU) and distribution uniformity of low quarter (DU_{lq}) have been studied. This study concluded that, the irrigation uniformity of sprinkler irrigation system was more affected by the combination of operating pressure, nozzle diameter and riser height.*

Keywords: Irrigation uniformity, Uniformity coefficients, Sprinkler irrigation system

1.0 INTRODUCTION

In recent years, the more efficient pressurized irrigation systems such as drip, trickle and sprinkler irrigation has became more usable instead of open channel irrigation system to increase the water use efficiency [1]. Sprinkler irrigation has been widely used around the world since 1950s, including wheel move, hand move, center pivot, solid set and other types of irrigation [2]. The irrigation uniformity is an important indicator for the evaluation of sprinkler irrigation systems performance. So, it must be consider during design and installation of the system [3,4]. Sprinkler applications require at least 85% CU and 80% DU_{lq}. Low values of CU and DU_{lq} indicate incorrect combination of nozzle size, operating pressure, and other design factors [4,5]. CU indicates both over and under irrigation, while DU_{lq} only considers the under irrigated area [6]. There are relevant factors affecting the irrigation performance of sprinkler irrigation system such as the type of sprinkler, nozzle diameter, operating pressure, and riser height [7,8]. Several studies have been conducted to investigate the effect of those design factors on the irrigation uniformity of sprinkler irrigation system. Haman et al. [9] emphasized that the most effective factor on the irrigation uniformity is operating pressure. Too high pressure produce small droplets that lead to higher water distribution near sprinkler. Also, too low pressure produce large droplets that fall further away from sprinkler. Sanchez et al. [10] performed study on the effect of pressure and nozzle diameter on the performance of agricultural impact sprinklers. It found that, when the nozzle diameter and pressure increased the atomization was enhanced, and the distribution became more homogenous. Montero *et al.*

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[11] evaluated the irrigation uniformity using combination of different pressure and riser height. They deduced that, low operating pressures were less affected by wind than high operating pressures. Also, the high irrigation uniformity was attained with high riser height.

Based on the previous studies, it is well known that the irrigation uniformity of sprinkler irrigation system is largely dependent on many factors such as operating pressure, nozzle diameter and riser height, but most of previous studies focused on one or maximum two of these factors. Therefore these factors need to be studied together as a combination factors. In this study an attempt was made to investigate the effect of combination factors operating pressure, nozzle diameter and riser height on sprinkler irrigation uniformity.

2.0 METHODOLOGY

2.1 Field experiment data

This study was conducted at University Technology PETRONAS in Perak state, Malaysia (4° 25′16.5936″N, 100° 59′26.5056″E) turfgrass area. The soil at the research site was classified as loamy soil. In this study a double nozzle impact sprinkler of full circle rotation was used. The square system (12 x12 m) was designed. This system was consisted of a low pressure centrifugal pump, PVC pipe, control valve, pressure gauge, flow rate meter and sprinklers. The main line of the system had 2 laterals with 40 mm diameter, 4 risers with 20 mm diameter. Different operating pressures (62, 82, 102, and 122 KPa) were selected. Different nozzles diameters (4, 5, 6 and 7 mm) with 2.4 mm auxiliary nozzle and different riser heights (0.5, 0.75 and 1.0 m) were used.

2.2 Block sprinkler test

The outdoor test was conducted using catch-cans method [3-11]. A number of 36 graduated catch-cans with 95 mm diameter and 108 mm height were used. The area between sprinklers was divided into square grids 2x2 m [12,13]. The sprinklers were located at the side of this area as shown in Figure 1. The system was run for one hour then the caught volumes were measured. The catch-cans data was used to determine uniformity coefficients.

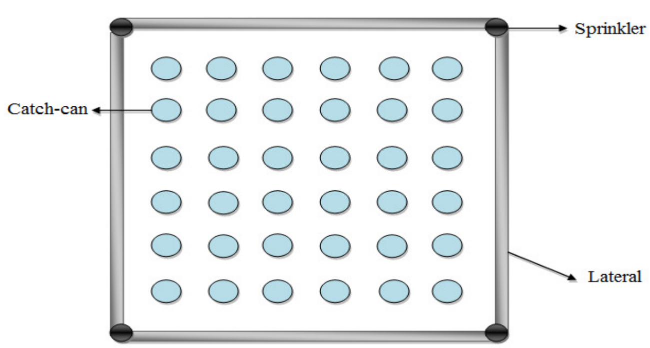

Figure 1: Catch cans arrangement in block sprinkler test

3.0 RESULTS AND DISCUSSION

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Figure 2 shows that with the nozzle 4mm, CU and DU_{lq} values were very low. CU increased as the pressure increased, CU values were low with the riser 0.5 m for the pressures 62 and 82 KPa, then it increased rapidly when the pressure increased. The higher values of CU were achieved with the riser-075 m. With the riser 1.0 m, CU values were high especially with 122 KPa. Figure 3 shows that the DU_{lq} increased as the pressure increased. DU_{lq} values were low with the riser 0.5 m for the pressures 62 and 82 KPa, then it increased rapidly with the increase of the pressure. The higher DU_{lq} values were achieved with the riser 1.0 m that can be explained by, with small nozzle when the height increases the water can be distributed for farther distance, then the area of under irrigated will be reduced that led to an improvement in DU_{lq} [11].

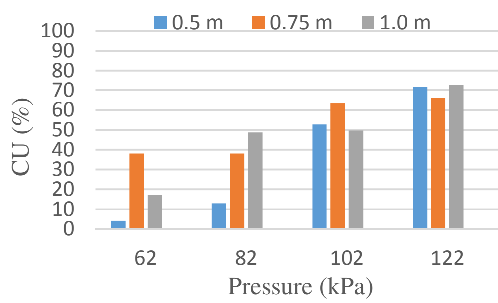

Figure 2: CU vs pressure for nozzle 4 mm

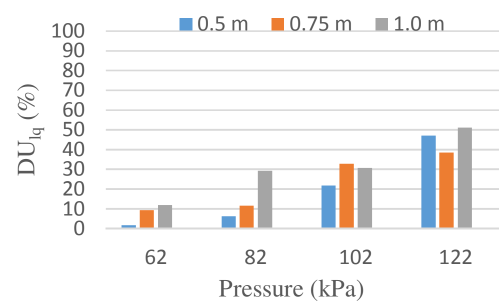

Figure 3: DU_{lq} vs pressure for nozzle 4 mm

Figure 4 shows that with the nozzle 5 mm CU increased as the pressure increased. The higher values of CU were achieved with the riser 0.75 m. Also, CU values were higher with the riser 0.5 m than with 1.0 m. Figure 5 shows that with the nozzle 5 mm. DU_{lq} increased as the pressure increased. The values of DU_{lq} were higher with the riser 0.5 m and lower with the riser1.0 m that can be reasoned by, with this combination the throwing distance was long that led to increase the water losses, thus increased under irrigated areas consequently decreased DU_{lq} value [12]. Figures 6 and 7 for nozzle 6 mm show the same trend that obtained with the nozzle 5 mm.

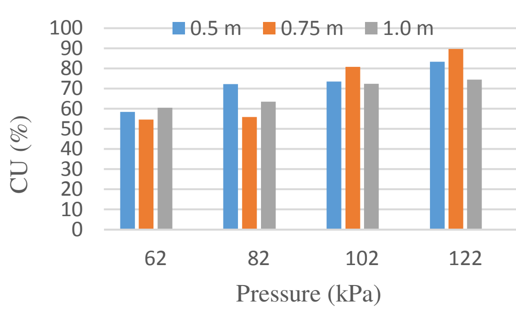

Figure 4: CU vs pressure for nozzle 5 mm

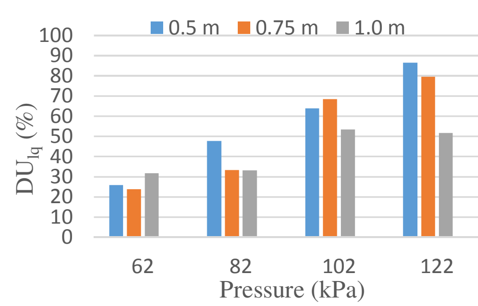

Figure 5: DU_{lq} vs pressure for nozzle 5 mm

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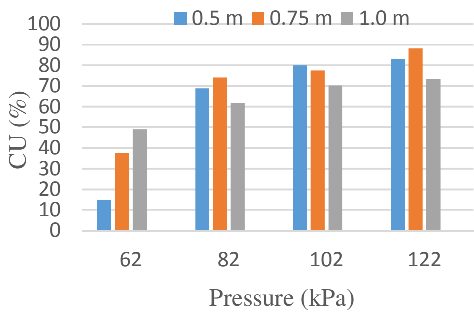

Figure 6: CU vs pressure for nozzle 6 mm

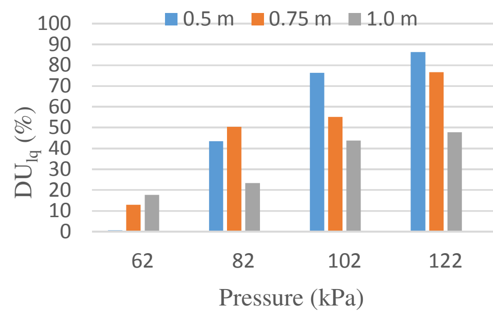

Figure 7: DU_{lq} vs pressure for nozzle 6 mm

Figure 8 shows that with the nozzle 7 mm, CU increased as the pressure increased. The higher values of CU were achieved with the riser 1.0. The lower values of CU were with the riser 0.75 m. Figure 9 shows that with the nozzle 7 mm, DUlq increased as the pressure increased. The higher values of DUlq were with the riser 1.0 and the lower DUlq values were with the riser 0.75 m.

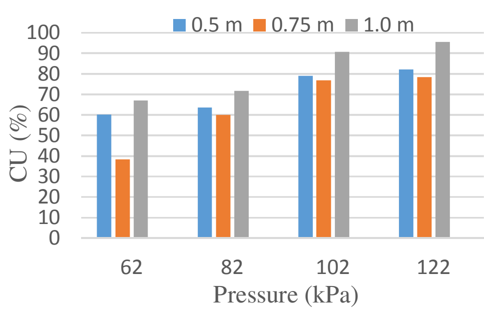

Figure 8: CU vs pressure for nozzle 7 mm

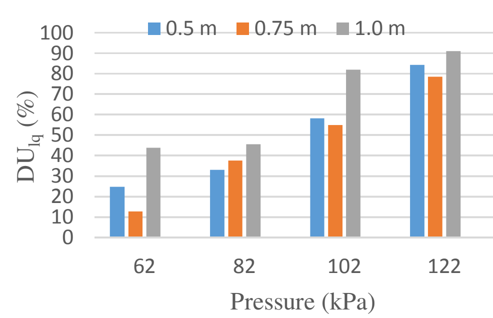

Figure 9: DU_{lq} vs pressure for nozzle 7 mm

4.0 CONCLUSION

In this study, the effect of combination factors operating pressure, nozzle diameter and riser height on sprinkler irrigation uniformity was presented. Generally, with the same nozzle, the CU and DU_{lq} increased with the increase of operating pressure for all riser heights. For all pressures, CU and DU_{lq} increased with the increase of nozzle diameter except with the combinations of 7 mm with 0.5 and 0.75 m risers, CU and DU_{lq} values were dropped. For the small nozzle, the low riser height gave better CU values and for big nozzle, the high riser height gave better CU values. For small and big nozzle the high riser height was the best option because it was helped the water distribution then improved the DU_{lq}, while the low riser height was better for the medium nozzle [13]. It can be concluded that; the irrigation uniformity of sprinkler irrigation system was more affected by the combination of operating pressure, nozzle diameter and riser height.

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