IRRIGATION WATER UNIFORMITY DISTRIBUTION FOR IMPACT SPRINKLERS

M. A. Aboamera
Agric. Eng. Dept., Fac. of Agric., Minufiya University
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ABSTRACT: *Three types of impact sprinklers (low, moderate and medium pressure) were tested by the aim of deriving the relationship between the operating pressure and the uniformity coefficients, Christiansen coefficient of uniformity (CU) and distribution uniformity (DU) in addition to their affect with both wind speed and the height of riser. An experimental layout was constructed and included all the required devices for measuring (CU) and (DU) and adjusting the system (centrifugal pump, sandy filter, pressure regulator, pressure gauge, flow meter, and a relief valve). The highest values of (CU) and (DU) were 94.98% and 90.63% respectively recorded at 350 and 325 kPa of the operating pressure for impact medium sprinklers at 1m height of riser. The combination of wind speed and riser height affected strongly the values of both (CU) and (DU), where the higher decrease in (CU) was about 4.83% and was about 7.68% for (DU if the riser height increased from 1 to 1.5m. Impact moderate pressure sprinklers achieved the highest percent of drift losses at 1 and 1.5m of riser height comparing with the other tested impact sprinklers. The highest drift losses percent was (23.43%) observed with impact moderate sprinkler at 1m height of riser and 225kPa of operating pressure.*

Key words: *Impact sprinklers, uniformity coefficient for impact sprinklers, wind speed and riser height, uniformity distribution.*

INTRODUCTION

Sprinkler heads are classified according to their operating pressure range and their position in relation to irrigated crops. In choosing sprinkler, the aim is to find the combination of sprinkler spacing, operating pressure and nozzle size that will most nearly provide the optimum water application rate with the greatest degree of uniformity distribution. The degree of uniformity obtainable with a set sprinkler system depends largely on the water distribution pattern and spacing of the sprinklers. Each type of sprinkler heads has certain precipitation characteristics that vary with nozzle size and operating pressure and result in an optimal range of operating pressure for each nozzle (Keller and Bliesner, 1990).

Riser height did not influence on evaporation and drift losses, either in single sprinkler or block irrigation. Evaporation and drift losses are higher in single sprinkler irrigation than in block irrigation. The reason can be found in the different microclimate that exists in both situations for different number of sprinklers working simultaneously. These differences are not only referred to the amount of their average values for similar climatic conditions, but they also have great effect on different explicative patterns (Ortega, *et al.*, 2000).

Water sprays from sprinklers breaks up into small drops between 0.5 and 4mm in size. The small drops fall close to the sprinkler whereas the larger ones fall close to the edge of the wetted circle. Large drops can damage delicate crops and soils and so in such conditions it is best to use the smaller sprinklers. Droplet size is also controlled by pressure and nozzle size. When the pressure is low, drops tend to be much larger as the water jet does not break up easily. In order to avoid crop and soil damage, smaller diameter nozzles operating at or above the normal recommended operating pressure should be used (Brouwer, *et al.*, 1988).

Droplet size for a large number and variety of sprinklers, including impact sprinklers with both square circular nozzles in shape and sprayers with several types of deflector plates 9 flat and grooved. The droplet size was measured by using the laser- optic method. The obtained results illustrated that, the working pressure over the sprinklers has more importance in the size of the droplet than the size of the nozzle. The results also showed that, the nozzle is more important than pressure in case of sprayers (Kincaid, 1996).

Working pressure has the most influence on droplet sizes, where under low pressure conditions; droplet with diameter of about 9mm can be formed. The greater the distance from the sprinkler, the greater the diameter of the droplets, following an exponential model. Working pressure is the main factor that influences droplet size distributions. Thus, as the working pressure decreases, the average droplet size increases. The ratio (Dq/H) of nozzle diameter (Dq) to operating pressure (H) is a useful parameter (Dq/H) to characterize the droplet size distribution of the impact sprinklers. The impact energy increased significantly as the simulated wind speed increased (Montero, *et al.*, (2003).

Nozzle elevation has little effect on drop energy. When using concept of spray evaporation losses it must be assumed that, the entire difference between the discharge volume and the collected one should be considered as losses. The reason is that, the microclimate generated above the crop during irrigation and the water retention by crop itself implies, among other effects substantial transpiration depletion (Kincaid, 1996).

The use of low pressure impact sprinklers and fixed head spray sprinklers has resulted in several modifications and the smaller wetted area of these sprinklers requires closer sprinkler spacing. Fixed head spray sprinklers can be mounted on drop tubes, with central pivot irrigation system, in which extend below the pipe to within a few centimeters of the crop (to minimize wind effects). Drop tubes are often alternately offset before and after of the pipe lateral to increase the area wetted and thus reduce the average application rate (James and Baliar, 1984).

In case of in – farm solid set irrigation, working pressure is important to explain the variability of losses. In addition, less quadratic tendency of losses with respect to vapor pressure deficit as a parameter of climatic items is shown. This could probably be attributed to the effect of block irrigation itself combined with the lower accuracy when measuring climatic parameters (Ortega, *et al.*, 2000).

Optimal spacing between impact sprinklers was found to be as 40% to 60% from diameter of throw in square layout in range of trajectory angles between 15 to 30 degrees. A high degree of uniformity was achieved for 21 degree of trajectory angle (Mahmoud *et al.*, 2007).

Most crops exceed 30 cm in height, except for clean, cultivated orchards where low riser pipes are desirable for under tree sprinkling, the choice will be the minimum height to clear the crop. Some research studies indicate that 30cm to 60cm an additional height improves the sprinkler distribution efficiency. However, there are obvious disadvantages to this, such as additional wind drift and problems with handling lateral pipes with long risers attached. Wind drift and evaporation losses may be as little as a few percent when irrigating a crop with a full vegetative canopy in low winds. Under more common conditions, wind drift and evaporation losses range between 5 and 10%. However under severe conditions, they can be considerably greater (Keller and Bliesner, 1990).

The main objective of this work was to evaluate the distribution uniformity coefficients (CU) and (DU) for three types of impact sprinklers (low, moderate and medium pressure) at different levels of the operating pressure and riser height. Which are used in designing sprinkler irrigation systems. Also to derive the relationship between the recorded value of wind speed and the water distribution uniformity coefficients. In addition to measure the drift losses percent occurred for each type of the impact sprinklers and its relation to wind speed and riser height.

MATERIALS AND METHODS

1. Experimental system layout

Field experimental layout was constructed in open field and it consists of centrifugal pump (3.6kW), sandy filter150 mesh, relief valve, flow meter, pressure regulator, pressure gauge, main line 23 mm diameter, three lateral lines16mm diameter, risers and impact sprinkler heads. The distance between the two consecutive laterals was 10m and also was 10m between sprinklers. For each type of the tested sprinklers, nine head were fitted where each lateral included three sprinkler heads. Figure (1) represents the experimental system layout which used in determining the Christiansen coefficient of uniformity (CU) and distribution uniformity (DU) by low quarter

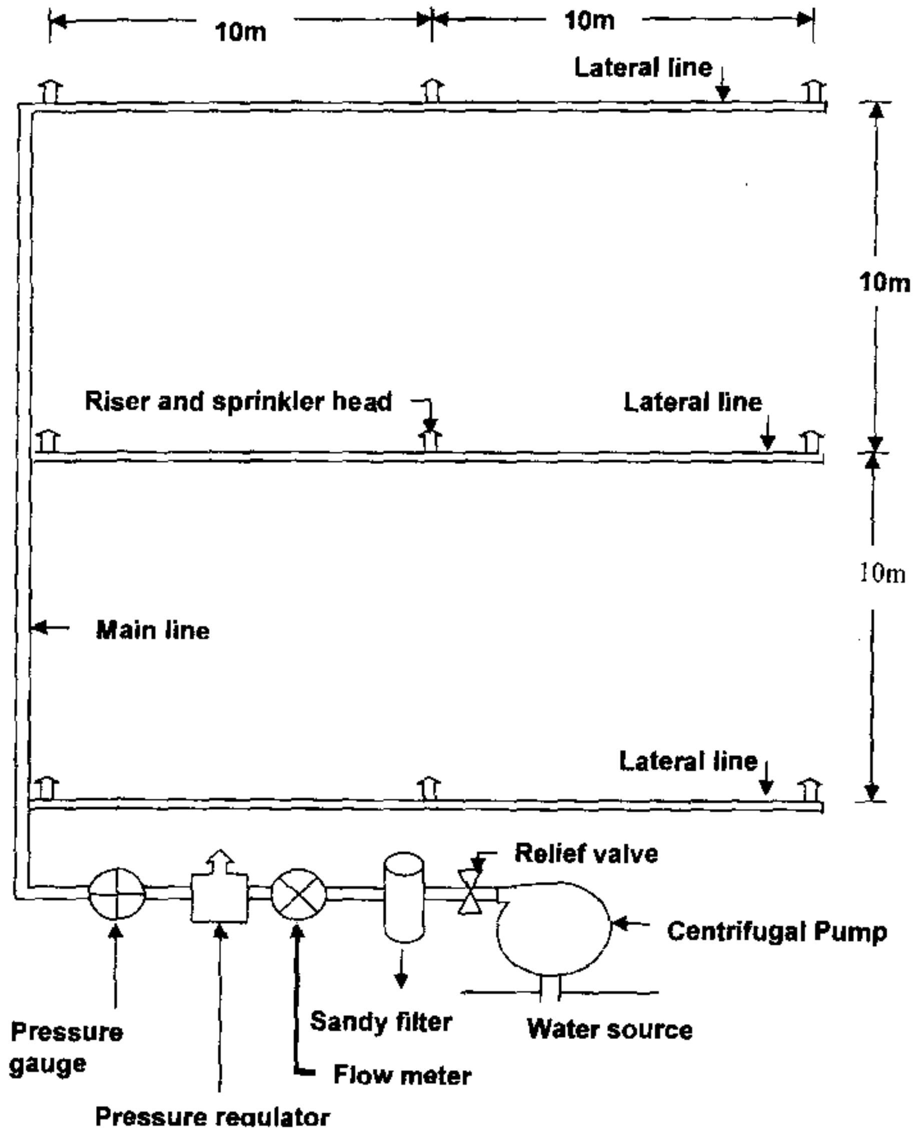

Fig. (1): Schematic diagram of the experimental layout which used in measuring distribution uniformity (DU) and uniformity coefficient (CU).

technique for each type of sprinkler at each level of operating pressure and riser height. Catch cans were arranged in rows and columns and each was spaced 1m apart. The water collected in each catch cane was measured in depth and the area between two lateral lines was occupied by 200 catch cane. This number of catch containers which arranged for the three laterals, simulates the total water falls in the area between the three laterals. The riser connected with the lateral line has the ability to be adjusted in two levels which are 1and 1.5m height from the ground surface. At each test, the operating pressure was adjusted and controlled by the pressure regulator and the system operates for 15 minutes then the collected water in each catch cane can be measured. During each test, wind speed was measured two times and the average value for each test was taken into consideration. The total water flows during the test was measured by the flow meter and the measured value for each test used in determine the drift losses percent.

2. Impact sprinkler heads

Three types of impact sprinkler heads were tested with the objective of deriving the variation in water distribution uniformity for each type due to the height of riser and the operating pressure with the value of wind speed which recorded at the experimental site. The three tested types were:

(a) Impact low pressure (operates at 75 – 100 - 125 –and 150kPa).
(b) Impact moderate pressure (operates at 175 – 200 – 225 and 250kPa)
(c) Impact medium pressure, (operates at 275 – 300 – 325 and 350 kPa).

The differences between the Christiansen coefficient of uniformity (CU), and distribution uniformity (DU) and drift losses percent due to changing height of riser and the operating pressure were used in differentiation between impact sprinklers. Each type of the tested impact sprinklers is considered an individual treatment and its results will analyze and discussed separately.

3. Uniformity distribution

The uniformity of sprinkler irrigation is usually quantified by the most common coefficient of uniformity proposed by Christiansen, 1942 using the following equation:

$$CU = 100 \left[1 - \sum x / n\, m\right] \qquad (1)$$

Where:

CU = Coefficient of uniformity defined by Christiansen, %

x = absolute deviation of the individual observation, mm

m = mean depth of observation, mm and n = number of observations.

To gauge the performance of an irrigation system, the low quarter distribution uniformity is used in sprinkler and drip irrigation systems, can be computed as follows (Burt *et al.*1997):

$$DUq = Vq / V \qquad (2)$$

Where:

DUq = the low quarter distribution uniformity (%)

Vq = the average volume caught in the lowest 25% of collected (ml), and

V = the overall average of volumes collected (ml).

At each level of both operating pressure and riser height, the test was replicated three times and the collected water was measured. Hence, the value of (CU) and (DU) at each level of operating pressure and riser height can be computed. In each test, the average recorded wind speed was considered and the total water flow was observed.

4. Drift losses percent and wetted diameter

Evaporation and drift losses for each type of the impact sprinklers at each level of the operating pressure and riser height was calculated by dividing the total quantity of the water collected in catch cans by the quantity of the flow water measured by the flow meter during the experiment. Drift losses occurred will be changed due to both of the operating pressure and the riser height in addition to the average value of wind speed. The value of drift losses percent can be used as an effective parameter in differentiation between the three types of the impact sprinkler. Wetted diameter for each test was measured for each replication and its average value was used in calculating the interference percent considering that the distance between risers and lateral spacing is 10m.

RESULTS AND DISCUSSION

1. Operating pressure and riser height

Table (1) represents the variation of both (CU) and (DU) due to changing operating pressure and height of riser for the three tested sprinkler heads. Impact low pressure and moderate pressure sprinklers take the same trend for the values of (CU) and (DU), where they increased as the operating pressure increased and then decreased at the higher value of the operating pressure. With impact medium pressure sprinklers, the value of (CU) and (DU) either for 1m or 1.5m height of riser, increased as the operating pressure increased. The highest value of (CU) was 82.34% occurred at 100kPa of the operating pressure and the highest value of (DU) 71.93% was also occurred also at 100kPa. For impact moderate pressure sprinklers, these values were 88.88% for (CU) and 82.32% for (DU) which observed at 225 kPa of the operating pressure. As for the impact medium pressure sprinklers the values of (CU) and (DU) were 94.98% and 90.63% respectively recorded at 350 and 325 kPa of the operating pressure. The above values were obtained at 1m of the riser height. At each type of impact sprinklers, riser height of 1.5m above the ground surface, resulted in lower values of both (CU) and (DU) comparing with 1m height. The results listed in table (1) recommended using each type of the impact sprinkler heads at a height of

1m above the ground surface. It can also concluded the moderate pressure impact sprinklers for almost all crops because of its accepted values of (CU) and (DU) in addition to be operates at a mean value of pressure which will caused decreasing the operating costs. Finally, for impact medium pressure sprinklers, it can be used where the higher values of both (CU) and (DU) are required and to be operates at its higher limit of the operating pressure.

Table (1): Christiansen coefficient of uniformity (CU) and distribution uniformity (DU) for the three types of impact sprinklers as related to operating pressure and riser height

Sprinkler type	Operating pressure (kPa)	Riser height (m)			
		1		1.5	
		Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %	Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %
Impact low pressure	75	80.17	68.47	78.93	66.50
	100	82.34	71.93	81.27	70.22
	125	82.33	71.91	80.51	69.01
	150	79.69	67.70	79.18	66.90
Impact moderate Pressure	175	84.04	74.62	79.21	66.94
	200	88.69	82.02	86.62	78.72
	225	88.88	82.32	84.81	75.85
	250	83.82	74.72	84.15	74.80
Impact medium pressure	275	90.84	85.43	84.44	76.26
	300	92.01	87.30	89.40	83.15
	325	93.76	90.63	86.24	78.12
	350	94.98	90.01	92.54	88.14

2. Effect of wind speed

Studying the effect of wind speed on the uniformity coefficients was based on measured and calculated both of (CU) and (DU) at a medium range of wind speed (i.e. from 8 to 12 km/h except for low pressure impact sprinkler, where the higher value of wind speed did not exceed 10.45km/m). Therefore, for each type of the impact sprinklers, the values of Christiansen coefficient of uniformity (CU) and distribution uniformity (DU) were considered at this range. Figure (2) represents the changing of (CU) and (DU) due to changing the magnitude of wind speed for impact low pressure sprinklers, at 1 and 1.5m of riser height. At the same value of wind speed, increasing riser height from 1 to 1.5m resulted in decreasing (CU). The higher the riser height, the lower the value of (CU) and (DU) for low pressure impact sprinklers at the medium range of wind speed. At the higher value of wind speed (10.45km/h), the value of (CU) decreased by 1.82 % as the riser height increased from 1 to 1.5m over the ground surface as presented in table (2). As for the distribution uniformity (DU) its value decreased at all values of wind speed except at 8.75 km/h as the riser height increased from 1 to 1.5m . at the same height of riser both of (CU) and (DU) decreased as the wind speed increased.

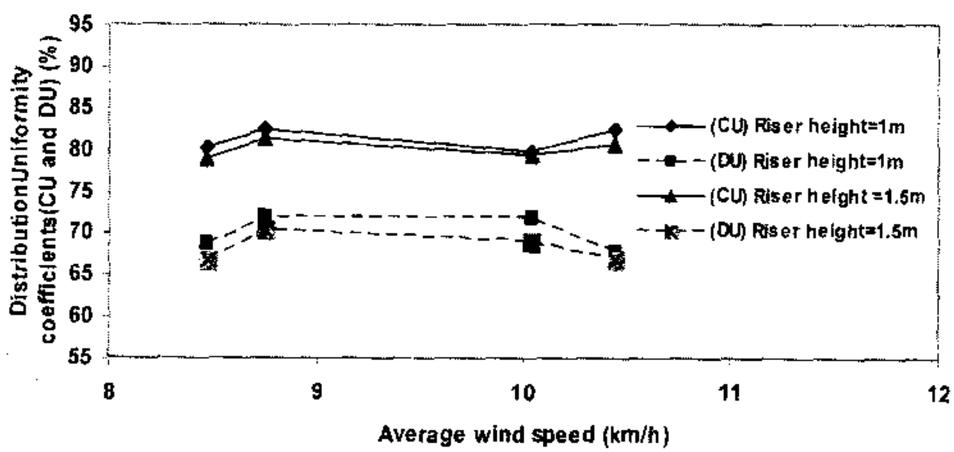

Fig (2) : Christiansen coefficient(CU) and distribution (DU)uniformities as related to wind speedand riser height for impact low pressure sprinklers

Table (2): Changing of (CU) and (DU) with wind speed for low pressure impact sprinklers at the two levels of riser height.

Wind speed (km/h)	Riser height (m)			
	1		1.5	
	Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %	Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %
8.47	80.17	68.47	78.93	66.50
8.75	82.34	61.93	81.27	70.22
10.04	79.69	71.91	79.18	69.01
10.45	82.33	67.70	80.51	66.90

Figure (3) represents the changing of (CU) and (DU) for impact moderate pressure sprinklers at the same range of wind speed. The same trend was observed, where as the riser height increased, the value of (CU) and (DU) decreased at the same value of wind speed except at 8.83km/h. Table (3) showed that, increasing wind speed from 9.15 to 11.82 km/h led to decrease the value of (CU) and (DU), but the decreasing was not much greater than the effect of riser height. In some cases, at the higher value of wind speed the value of (CU) decreased slightly as the riser height increased from 1m to 1.5m. However, the combination of wind speed and riser height affected strongly the values of both (CU) and (DU), where the higher decrease in (CU) was about 4.83% (84.04 -79.21) and by about 7.68% (74.62 -66.94)if the riser height increased from 1 to 1.5m.

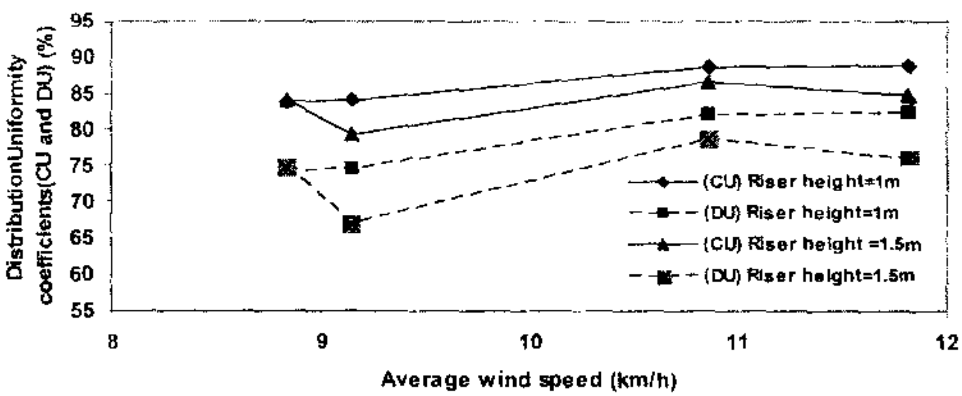

Fig (3) : Christiansen coefficient (CU) and distribution (DU) uniformities as related to wind speedand riser height for impact moderate sprinklers

Table (3): Changing of (CU) and (DU) with wind speed for moderate pressure impact sprinklers at the two levels of riser height

Wind speed (km/h)	Riser height (m)			
	1		1.5	
	Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %	Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %
8.83	83.82	74.72	84.15	74.80
9.15	84.04	74.62	79.21	66.94
10.86	88.69	82.02	86.62	78.72
11.82	88.88	82.32	84.81	75.85

For impact medium pressure sprinklers, the trend of (CU) and (DU) was changed due to change wind speed and riser height as presented in Figure (4). Decreasing of (CU) and (DU) due to changing wind speed and riser height was greater as compared with both low pressure and moderate pressure impact sprinklers.

The value of (CU) and (DU) decreased by 4.14 and 4.58%respectively as the wind speed increased from 8.65 to 11.14 km/h at 1m of riser height. As the riser height increased to 1.5m both of (CU) and (DU) decreased at all values of wind speed as presented in table (4).

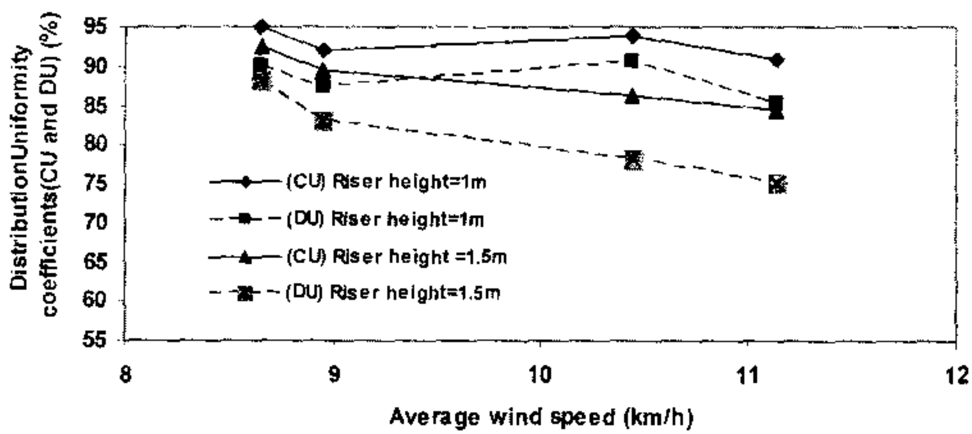

Fig (4) : Christiansen coefficient (CU) and distribution (DU)uniformities as related to wind speed and riser height for impact medium sprinklers

Table (4): Changing of (CU) and (DU) with wind speed for mediate pressure impact sprinklers at the two levels of riser height.

Wind speed (km/h)	Riser height (m)			
	1		1.5	
	Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %	Christiansen coefficient of uniformity (CU) %	Distribution uniformity (DU) %
8.65	94.98	90.01	92.54	88.14
8.95	92.01	87.30	89.40	83.15
10.45	93.75	90.63	86.24	78.12
11.14	90.84	85.43	84.44	75.26

3. Drift losses percent

Drift losses percent is considered an important parameter that differentiates between the three types of the impact sprinklers. Table (5) represents the drift losses percent which calculated for the three types of impact sprinklers at 1 and 1.5m of riser height. Drift losses percent decreased for low pressure impact sprinklers as the riser height increased from 1 to 1.5m except at 125kPa of the operating pressure and 10.45km/h of wind speed. The highest percent of drift losses that occurred with impact low pressure sprinklers was 16.4% and 11.75% at 1 and 1.5m of riser height respectively. The lowest value was 6.82% achieved at 1.5m of riser height with the higher value of the operating pressure (150kPa) and higher value of wind speed (10.04km/h).

Impact moderate pressure sprinklers achieved the highest percents of drift losses at 1 and 1.5m of riser height comparing with the other types. The highest percent (23.43%) was observed at 1m height of riser at 225kPa of the operating pressure.

Impact medium pressure sprinklers recorded the lowest percents of drift at 1.5m of riser height comparing with the other types. Increasing the operating pressure led to increase the drift losses percent for the impact medium pressure at 1.5 m of the riser height. Increasing the height of riser from 1 to 1.5m decreased the drift losses percent for medium pressure impact sprinklers. While, in case of moderate pressure sprinklers, at both 175 and 250kPa of the operating pressure, the drift losses percent increased as the riser height increased. The value of the drift losses percent depended upon the combination of both wind speed and the operating pressure at the same height of riser. Therefore, in choosing any type of the tested impact sprinklers, it must be taken into account the value of wind speed and the operating pressure then choose the height of riser which might be adjusted. In case of impact medium pressure sprinklers, the higher values were 9.42 and 11.84% obtained at 1 and 1.5m of riser height respectively. While, the lowest percent (6.85%) was observed at 1.5m of the riser height at 275 kPa of the operating pressure and 8.65 km/h of wind speed. Impact moderate pressure sprinklers could not be recommended due to the higher percent of drift losses either in 1 or 1.5m of the riser height.

Table (5): Drift losses percent as related to sprinkler type and operating pressure at 1and 1.5m of riser height with the recorded wind speed at the experimental location

Sprinkler type	Operating pressure (kPa)	Wind speed (km/h)	Drift losses (%)	
			Riser height (1m)	Riser height (1.5m)
Impact low pressure	75	8.47	12.78	10.25
	100	8.75	16.4	10.60
	125	10.45	11.05	11.75
	150	10.04	9.42	6.82
Impact moderate Pressure	175	9.15	14.09	18.26
	200	10.86	14.09	13.73
	225	11.82	23.43	14.56
	250	8.83	16.48	16.87
Impact medium pressure	275	8.65	9.17	6.85
	300	8.95	9.42	8.69
	325	10.45	8.95	8.29
	350	11.14	8.69	11.84

4.Wetted diameter

Wetted diameter for each type of impact sprinklers was measured at each level of the operating pressure and riser height. The interference percent was calculated considering that both sprinkler spacing and lateral spacing are

10m as presented prior in figure (1). The measured value of the wetted diameter and the calculated percent of the interference were listed in table (6) for all types of the impact sprinklers. At 1m of the riser height for impact low pressure sprinklers, the higher wetted diameter was 17m observed at 150kPa of the operating pressure and 10.04km/h of wind speed. In this type of impact sprinkler, the wetted diameter did not increase greatly due to increase the height of riser and consequently, the interference percent did not affect. In case of moderate pressure impact sprinklers, the value of wetted diameter changed largely at 175 kPa of the operating pressure as the riser height increased from 1 to 1.5m. Impact medium sprinklers resulted in lower wetted diameter and interference percent comparing with low and moderate pressure impact sprinklers.

Table (6): Average wetted diameter as related to wind speed and operating pressure at 1and 1.5 m of riser height.

Sprinkler type	Operating pressure (kPa)	Wind speed (km/h)	Average wetted diameter (m) Riser height (m)		Interference percent (%) Riser height (m)	
			1	1.5	1	1.5
Impact low pressure	75	8.47	16	16	60	60
	100	8.75	15	16	50	60
	125	10.45	15	17	50	70
	150	10.04	17	18	70	80
Impact moderate Pressure	175	9.15	12	15	20	50
	200	10.86	14	15	40	50
	225	11.82	15	16	50	60
	250	8.83	13	13	30	30
Impact medium pressure	275	8.65	14	13	40	30
	300	8.95	14	14	40	40
	325	10.45	15	16	50	60
	350	11.14	15	15	50	50

CONCLUSION

In choosing the appropriate impact sprinkler head, the combination of both operating pressure and riser height might be taken into consideration. Impact medium pressure sprinkler heads achieved the highest values of both Christiansen coefficient of uniformity (CU) and distribution uniformity (DU) and it can be recommended to be used in solid set sprinkler irrigation systems. Impact moderate sprinklers gave a higher value of drift losses percent, hence it can not be recommended to be used especially where the wind speed is higher. Also the value of wind speed effect on the uniformity distribution for all types of the impact sprinklers.

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انتظامية توزيع مياه الري للرشاشات التصادميه

محمد على أبوعميرة

قسم الهندسة الزراعية – كلية الزراعة جامعة المنوفية

الملخص العربى

أجريت هذة الدراسة بالمزرعة التجريبية التابعة لجامعة المنوفية بمدينة السادات واستهدفت استنباط العلاقة بين انتظامية توزيع مياه الرى لثلاثة أنواع مختلفة لرشاشات التصادم هى: رشاشات التصادم منخفضة الضغط (٧٥– ١٠٠– ١٢٥– ١٥٠ كيلوباسكال) ،رشاشات التصادم متوسطة الضغط (١٧٥– ٢٠٠– ٢٢٥– ٢٥٠ كيلوباسكال)، رشاشات التصادم عالية الضغط (٢٧٥– ٣٠٠– ٣٢٥– ٣٥٠ كيلوباسكال) مع قيمة سرعة الرياح فى ارض التجربة وتمثلت هذه الدراسة فى قياس وحساب معامل كريستيانسن للأنتظامية (CU) وانتظامية التوزيع (DU) لأقل ربع بالاضافة الى حساب نسبة التشتت لكل نوع و تم اجراء التجارب عند كل ضغط من ضغوط التشغيل الملحقة بكل رشاش. ولتحقيق هذا الهدف تم عمل منظومة للرى بالرش مكونة من خط رى رئيسى وثلاث خطوط رى فرعية طول كل منها ٢٠متر وتم تركيب ثلاثة رشاشات على كل خط من خطوط الرى الفرعية وضعت على مسافة ١٠ متر فيما بينها وروعى أن يكون حامل الرشاشات المركب على خط الرى الفرعى ذو امكانية تغيير الأرتفاع بحيث يمكن التشغيل على ارتفاع ١متر ،١,٥ متر من سطح الأرض وعند كل اختبار تم تسجيل سرعة الرياح أثناء التشغيل ووزعت أواني التجميع بين خطوط الرى الفرعية وعلى مسافات متساوية فيما بينها. وتوصلت الدراسة الى النتائج الأتية:

(١) تحققت أعلي قيم لكل من (CU)&(DU) ومقدارها ٧١,٩٣% &٨٢,٣٤% لرشاشات التصادم منخفضة الضغط، ٨٢,٣٢% &٨٨,٨٢% لرشاشات التصادم متوسطة الضغط،٩٠,٦٣% &٩٤,٩٨% لرشاشات التصادم عالية الضغط عند ارتفاع ١متر لحامل الرشاشات وبضغط تشغيل مقداره ، ١٠٠ ، ٢٢٥ & ٣٥٠ كيلوباسكال على الترتيب.

(٢) أدت زيادة ارتفاع حامل الرشاشات من ١ متر الى ١,٥ متر الى نقص في قيمـــة (CU) بقيمة متوسطة مقدارها ١,٨٢% لرشاشات التصادم منخفضة الـضغط وبقيمـــة ٤,٨٣% لرشاشات التصادم متوسطة الضغط بينما كان النقص بمقدار ٤,١٤ % لرشاشات التصادم عالية الضغط.

(٣) أدت زيادة سرعة الريح في المدى المقاس (من ٨ الى ١٢ كم/س) وعند نفـس الأرتفـاع لحامل الرشاشات الى نقص فى كل من (CU)&(DU).

(٤) تحققت أعلى قيمة لنسبة التشتت ومقدارها ٢٣,٤٣% لرشاشات التصادم متوسطة الضغط عند ارتفاع ١ متر لحامل الرشاشات وعند ضغط تشغيل مقداره ٢٢٥ كيلوباشكال.

(٥) تحققت أقل قيمة لنسبة التشتت ومقدارها ٦,٨٢% لرشاشات التصادم منخفضةالضغط عند ارتفاع ١,٥ متر لحامل الرشاشات وعند ضغط تشغيل مقداره ١٥٠ كيلوباشكال.

(٦) أكبر قطر لدائرة الأبتلال ومقداره ١٨ متر و أعلى نسبة تـداخل مقـدارها ٨٠% تحققتـا لرشاشات التصادم منخفضة الضغط عند ارتفاع ١,٥ متر لحامل الرشاشات وضغط تشغيل ١٥٠كيلوباسكال.