Misr J. Ag. Eng., 26(3): 1201- 1222 IRRIGATION AND DRAINAGE

EFFECT OF SPRINKLER IRRIGATION UNIFORMITY ON WHEAT PRODUCTIVITY, WATER LOSSES AND WATER USE EFFICIENCY

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ABSTRACT

The current study was carried out at Agricultural and Veterinary Research Station, Faculty of Agriculture and Veterinary Medicine, Qassim University, Kingdom of Saudia Arabia during 2007/08 wheat growing season. The objective of this study is to investigate the effect of sprinkler irrigation uniformity on sprinkler irrigation uniformity coefficient on water losses by deep percolation, wheat crop yield and height, water use efficiency, uniformity coefficient of crop yield and height through field experiments. The other purpose is to obtain the response of wheat crop height yield to seasonal applied water. Treatments consisted of five sprinkler irrigation uniformity: "CUc1" (>90- <95%), "CUc2" (>80- <85%),"CUc3" (>70- <75%), "CUc4" (>60- <65%) and "CUc5" (>50- <55%). The results indicated that sprinkler irrigation uniformity coefficient affected all parameters of this study. By increasing sprinkler irrigation uniformity wheat crop yield, plant height, adequacy of irrigation and water use efficiency were increased while water losses by deep percolation and irrigation insufficient were decreased. High irrigation uniformity enhanced wheat growth, water use efficiency and worse water losses by deep percolation. Uniformity coefficient values for crop height, grain yield and water use efficiency of wheat were higher than the values of sprinkler irrigation Uniformity coefficient.

INTRODUCTION

To use water with economical and sustainable, water resources have to be utilized in such a manner as to protect and conserve the available water reserves ***(Sezen and Yazar, 2006)***. In irrigated agriculture this will have to be obtained through the effective management of water consumption.

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Therefore, irrigation systems will have to apply water in the most efficient way possible to prevent unnecessary losses and water wastage (***Burt et al. 1997***). In order to achieve this, the uniformity coefficient with which the irrigation system applies water will have to be high. The uniformity coefficient of a sprinkler irrigation system has a directly effect on the system's application efficiency and on the crop yield ***(Li and Rao, 2000)*** and ***(Dechmi et al., 2003)***. Poor distribution uniformity experience reduced yields due to water stress. Poor distribution uniformity also has increased financial and environmental costs. Nutrients can be leached out of the soil due to excess water being applied to overcome poor irrigation uniformity (***Clemmens and Solomon, 1997).*** crop yield increased clearly with increasing sprinkler uniformity ***Li (1998); while (Mateos et al., 1997 and Li and Rao, 2000***) showed sprinkler uniformity had minor effect on crop yield. Application CV as high as 0.48 did not influence yield of cotton compared to uniformly irrigated (CV = 0.20) plots (***Mateos et al., 1997***). Although the authors speculated that part of the reason for no influence on yield was because cotton is a drought tolerant crop. ***Ayers et al. (1990***) found that uniformity coefficient as low as CU = 60% reduced average yield of sugar beet. ***Pang et al. (1997)*** reported that decreasing Christiansen uniformity coefficient (CU) from 100 to 75% caused a significant increase in water losses by deep percolation, nitrate leaching and a reduction of yield.

The catch can test is a commonly used measurement tool to assess the uniformity of sprinkler systems. The Christiansen Uniformity Coefficient is (***Christiansen, 1941; ASAE, 2001***) is commonly used in agricultural sprinkler uniformity assessment and is expressed as, In addition, the coefficient of variation (CV) in application volume can be computed as the standard deviation of all catch can measurements divided by the average catch can volume for a test, (***Dukes, 2006***). The distribution uniformity of an irrigation system depends both on the system characteristics and on managerial decisions (***Pereira, 1999*)**.

The objective of this study is to investigate the effect of sprinkler irrigation uniformity on sprinkler irrigation uniformity coefficient on water losses by deep percolation, wheat crop yield and height, water use efficiency, uniformity coefficient of crop yield and height through field experiments. The other purpose is to obtain the response of wheat crop height yield to seasonal applied water.

MATERIALS AND METHODS

Field experiments were conducted during 2007/2008 wheat growing season at Agricultural and Veterinary Research Station, Faculty of Agriculture and Veterinary Medicine, Al-Qassim University. The geographical location of the farm is 26^{o} $18^{'}$ N latitude and 43^{o} $58^{'}$ E longitude and 725 m altitude. The soil type of this experimental farm is classified as a sandy soil, 96.3% sand, 1.8% silt and 1.9% clay. The field capacity by weight was 13%, the wilting point was 4% by weight, the intake rate was 48 mm/h and the bulk density was 1.51gm.cm^{-3} and low organic matter 0.09g.kg^{-1}. The irrigation water was obtained from local well. The irrigation water has a pH of 7.11 and total soluble salts of 945 ppm. Sodium adsorption ratio (SAR) value was 2.66.

The field study included designing a solid set sprinkler irrigation system, which provided five different levels of Christiansen uniformity coefficient "CUc". They were >90- <95% (CUc1), >80-< 85% (CUc2), >70-<75% (CUc3), >60- <65% (CUc4) and >50-<55% (CUc5). These levels of uniformity coefficient were obtained by using impact sprinklers with different nozzle diameter and different operating pressure. The experimental design was randomized complete block with five treatments of sprinkler irrigation uniformity coefficient "CUc". Each treatment contained 3 replicates. Each plot was 8 m × 8 m in size, and sprinklers mounted on the 150-cm height risers were installed at each corner of the plot. Four sprinklers applied water to an experimental plot using a rotation angle of approximately 90° during irrigation. Sprinklers were operated at pressures of 300, 250, 200, 175 and 150 kPa for sprinkler irrigation uniformities CUc1, CUc2, CUc3, CUc4 and CUc5, respectively. A buffer zone of 2 m separated between treatments and 1 m separated between replicates to avoid interference. Each plot had one flow meter, one pressure regulator and pressure gauge to control the operating pressure and measure the quantity of applied irrigation water.

Catch cans of 120 mm diameter and 200 mm height were used to collect irrigation water. Each 8 m × 8 m plot was divided into a grid of sixteen 2 m × 2 m subplots. Sixteen catch cans were placed at the center of each subplot 70 cm above soil surface. For all the experiments, the average application rate ranged from 10 to 18 mm/h, and no surface runoff was found in the experiments.

Sprinkler water uniformity coefficient tests as well as applied and collected irrigation water depths were performed at each plot during the irrigation season (nine irrigation tests events). The experiments were carried out before and during the wheat growth. One before wheat grown and eight during wheat growth, in November 2007 – April 2008. Sprinkler evaluations were done according to the methodology of ***Merriam and Keller (1978)*** and ***Merriam et al. (1980)***. The duration of each experiment was determined in such a manner that the water collected depth resulting from the overlapping of wetted diameters is equivalent to the irrigation depth required for each irrigation event. Irrigations were performed when the calculated soil water balance reached 60% of the total available water within top 30-cm layer for fist month, then within top 60 cm after this month. (about 24.5mm and 48.9 mm depletion for first month and for next days respectively). Each irrigation event lasted for the time required to regain field capacity.

Wheat water requirement (ET) was estimated using the Penman–Monteith formula (***Smith, 1992)***. The crop coefficient of wheat adopted during the crop season 2007/08 were 0.55 (0; 20 days after grown)) - 0.65 (21; 50 days) - 1.15 (51; 100 days) - 0.30 (101-125 days), according to ***Mustafa et al. (1989*****).** Wheat (Yecora Rojo cultivar) crop was grown on 30th, November 2007. All other cultural practices were applied as recommended for wheat cultivation in Al-Qassim Region.

The necessary weather data were collected from an automated weather station was installed 250 m from the experimental field to monitor wind speed and direction, air temperature, humidity.

Characters evaluated involved agronomic characters and water productivity. Agronomic traits for wheat crop were taken on plant height and crop yield. Crop yield and plant height were measured from (1m*1m) central area of each subplot. The mean values of crop yield and plant height were determined for each plot. Christiansen uniformity coefficient values for crop height, grain yield and water use efficiency of wheat were determined depending in subplots data.

Christiansen uniformity coefficient "CUc", percentage of water losses by evaporation "EL" and percentage of water losses by deep percolation "Dp" and water use efficiency "WUE" were determined from equations1, 2, 3 and 4, respectively according to (***Keller and Bliesner, 2000)***

$$CUc = (1 - \frac{\sum_{i=1}^{N} abs(\mathrm{x}i - \mathrm{x})}{N * \mathrm{x}} * 100$$ Eq. (1)

EL= $\frac{Aw - Cw}{Aw} * 100$ Eq. (2)

Dp= $\frac{Cw - Sw}{Cw} * 100$ Eq. (4)

WUE = (Y /SAw) Eq.(5)

Where:-

CUc: is Christiansen uniformity coefficient, %;

xi: is the i^{th} water collected depth, mm;

x: mean of water collected depth, mm;

$\left(\sum_{i=1}^{N} abs(xi - x)\right)$: is the sum of the absolute deviation from the mean, x, of all N observations mm;

El= Percentage of water losses by evaporation, %;
Aw= Applied water depth, mm;
Cw= Collected water depth, mm;
Sw = water needed to regain field capacity in root zone, mm;
WUE = water use efficiency, $kg.m^{-3}$;
Y = the crop yield, $kg.m^{-2}$;
SAw = the seasonal amount of applied water, m3 $.m^{-2}$.

Analysis of variance was used to evaluate the responses of each studied character in wheat crop. Where a significant F-test was found the mean values were separated using Duncan's multiple range test. All analyses of variance were computed using the MSTATC microcomputer program (MSTATC, 1990).

RESULTS AND DISCUSSION

1. Climatic conditions in the experimental sit during the irrigation tests.

The average values of climatic conditions (wind speed, relative humidity and air temperature) in the experimental sit during season 2007/08 for nine irrigation tests events are shown in table (1). The data revealed that irrigation tests were carried out under conditions of relative humidity ranged from 50% to 68%, air temperature ranged from 16 ^{o}c to 30 ^{o}c and wind speed ranged from 4.1 km/h to 4.8 km/h. The maximum values of air temperature and wind speed were obtained at irrigation test number 9 on 30th March, while the maximum value of relative humidity was obtained at irrigation test number 5 on 30th January. The minimum values of wind speed, air temperature and relative humidity were obtained at irrigation test number 1 on 25th November, irrigation test number 5 on 30th January and irrigation test number 9 on 30th March, respectively.

Table (1): Mean values of Climatic conditions in the experimental sit during the irrigation tests.

No. of irrigation test	Date of irrigation test	Mean values of Climatic conditions		
		Wind speed (m/h)	Relative humidity (%)	Temperature (^oc)
Test1	25 Nov.	4.1	53	24
Test 2	15 Dec.	4.1	62	19
Test 3	30 Dec.	4.2	60	18
Test 4	15 Jan.	4.2	65	17
Test 5	30 Jan.	4.4	68	16
Test 6	15 Feb.	4.5	60	19
Test 7	27 Feb.	4.7	59	21
Test 8	15 Mar.	4.7	55	25
Test 9	30 Mar.	4.8	50	30
mean		4.41	59.11	21

2. **Uniformity coefficient of irrigation water.**

Table (2) shows the values of uniformity coefficient of irrigation water "CUc" for nine irrigation tests events. The data revealed that the maximum values of measured irrigation uniformity were obtained at irrigation test number 2 events on 15th December for all treatments where the air temperature and wind speed were low and the relative humidity was height, table (1). While the minimum values of measured irrigation uniformity were obtained at irrigation tests number 9 events on 30th Mar for all treatments where the climatic conditions were inversed of those at irrigation test number 2.The values of measured irrigation uniformity for all irrigation tests at the range of irrigation uniformity design. The mean values of irrigation uniformity were 91.42, 81.76, 72.12, 62.50 and 53.3% for treatments CUc1, CUc2, CUc3, CUc4 and CUc5

Table (3) shows correlation factors between the values of measured irrigation uniformity and the climatic conditions (wind speed, relative humidity and air temperature). The data revealed that wind speed had the highest effect on irrigation uniformity. In general, the irrigation uniformity coefficient decreased as wind speed and air temperature increased and as relative humidity decreased.

Table (2): Water uniformity coefficient for nine irrigation tests.

No. of irrigation test	Date of Test	**Uniformity coefficient of irrigation** (%)				
		CUc 1	CUc 2	CUc 3	CUc 4	CUc 5
Test1	25 Nov.	91.60	82.50	73.50	63.10	54.10
Test 2	15 Dec.	92.50	83.10	74.2	63.40	54.60
Test 3	30 Dec.	92.00	82.50	73.00	63.00	53.90
Test 4	15 Jan.	92.30	82.60	72.10	62.30	53.60
Test 5	30 Jan.	91.80	81.60	72.10	62.50	54.10
Test 6	15 Feb.	91.00	81.50	71.40	62.00	53.60
Test 7	27 Feb.	90.90	80.90	71.20	62.5	52.50
Test 8	15 Mar.	90.60	80.65	71.30	61.90	52.00
Test 9	30 Mar.	90.10	80.60	70.30	61.80	51.60
mean		91.42	81.76	72.12	62.50	53.34

Table (3): correlation factors between irrigation uniformity coefficient and climatic conditions

Climatic conditions	Correlation factor with "CUc"
W	-0.913
RH	0.702
T	-0.782

3. **Effect of climatic conditions on water losses by evaporation.**

The measurements of climatic conditions and water losses by evaporation during nine irrigation tests events and for five levels of irrigation uniformity showed insignificant variations between them. Therefore, table (4) shows the percentage of average values of water losses by evaporation for five treatments of irrigation uniformity during the nine irrigation events. The data revealed that the values of water losses by evaporation were varied as weather conditions varied. Table (5) shows the correlation factor between water evaporation losses and the climatic conditions (wind speed -relative humidity and air temperature). The data revealed that air temperatures had the highest effect on water evaporation losses then the relative humidity, while wind speed had the lowest effect on it. The water losses by evaporation increased as relative humidity decreased and as air temperature and wind speed increased. The maximum value of water losses by evaporation was 14.2 % for irrigation test number 9 on 30th March where the air temperature and wind speed were height and the relative humidity was low. While the minimum value was 9.0 % for irrigation test number 5 on 30th January where the climatic conditions were inversed of those on 30th March.

Multi regression analysis on the experimental field data was applied, to find the relation between evaporation losses percentage "EL" and the affecting factors of climatic conditions. The relation between "EL" and the affecting factors of climatic condition was found to be as shown in equation (6).

EL=-3.831 + 0.0213*W+ 0.07987*RH + 0.454*T   Eq. (6)

R^2= 0.955

Where:-

W = wind speed. (range 4.1 to 4.8 km/h)

RH= relative humidity. (range 50% to 68%)

T = air temperature (range 16 to 30)

Table (4): Mean values of applied water depth, received water depth and evaporation losses percentage during the nine irrigation tests.

No. of irrigation test	Date of irrigation test	Applied water depth (mm)	Received water depth (mm)	Evaporation losses percentage (%)
Test1	25 Nov.	56.18	50	11.0
Test 2	15 Dec.	27.69	25	9.7
Test 3	30 Dec.	26.64	24	9.9
Test 4	15 Jan.	56.17	51	9.2
Test 5	30 Jan.	53.85	49	9.0
Test 6	15 Feb.	55.31	50	9.6
Test 7	27 Feb.	55.56	50	10.0
Test 8	15 Mar.	58.02	51	12.1
Test 9	30 Mar.	57.11	49	14.2
mean		49.61	44.33	10.52

Table (5): correlation factors between water evaporation losses and climatic conditions

Climatic conditions	Correlation factor with water evaporation losses
W	**0.637**
RH	**-0.870**
T	**0.960**

4. **Cumulative frequency of water distribution pattern, irrigation adequacy and irrigation insufficient for the five treatments of uniformity coefficient**

Fig.(1) shows the cumulative frequency of water distribution pattern for the five treatments of uniformity coefficient CUc1, CUc2, CUc3, CUc4 and CUc5. The depth of received water is normalized (value/ mean) in the figure.

The adequacy of irrigation "percentage of area received mean depth of received water or more" and irrigation insufficient "percentage of area received depth of water less than mean depth of received water" were determined from cumulative frequency of water distribution pattern, figure (1). The values of adequacy of irrigation and irrigation insufficient are shown in figure (2). The data revealed that the maximum value of irrigation adequacy was 68.5% for treatment CUc1, while the minimum value was 38% for treatment CUc5. The maximum value of irrigation insufficient was 62% for treatment CUc5, while the minimum value was 31.5% for treatment CUc1. By increasing irrigation uniformity the irrigation adequacy increased while irrigation insufficient decreased.

For irrigated area had insufficient irrigation, the degree of water stress increased by decreasing the received water depth. Figure (1) indicated that the last 20% of irrigated area (0.8 1.0 of irrigated area) received depth of water less than 0.55 of mean received water depth for treatment CUc5, while the corresponding area for treatment CUc1 received depth of water less than 0.9 of mean received water depth. By increasing irrigation uniformity coefficient, the received water depth for last 20% of irrigated area increased. From the above mentioned indicated that plants in this area for treatment CUc5 suffer from height water stress, while plants in the same area of treatment CUc1 did not suffer from any water stress.

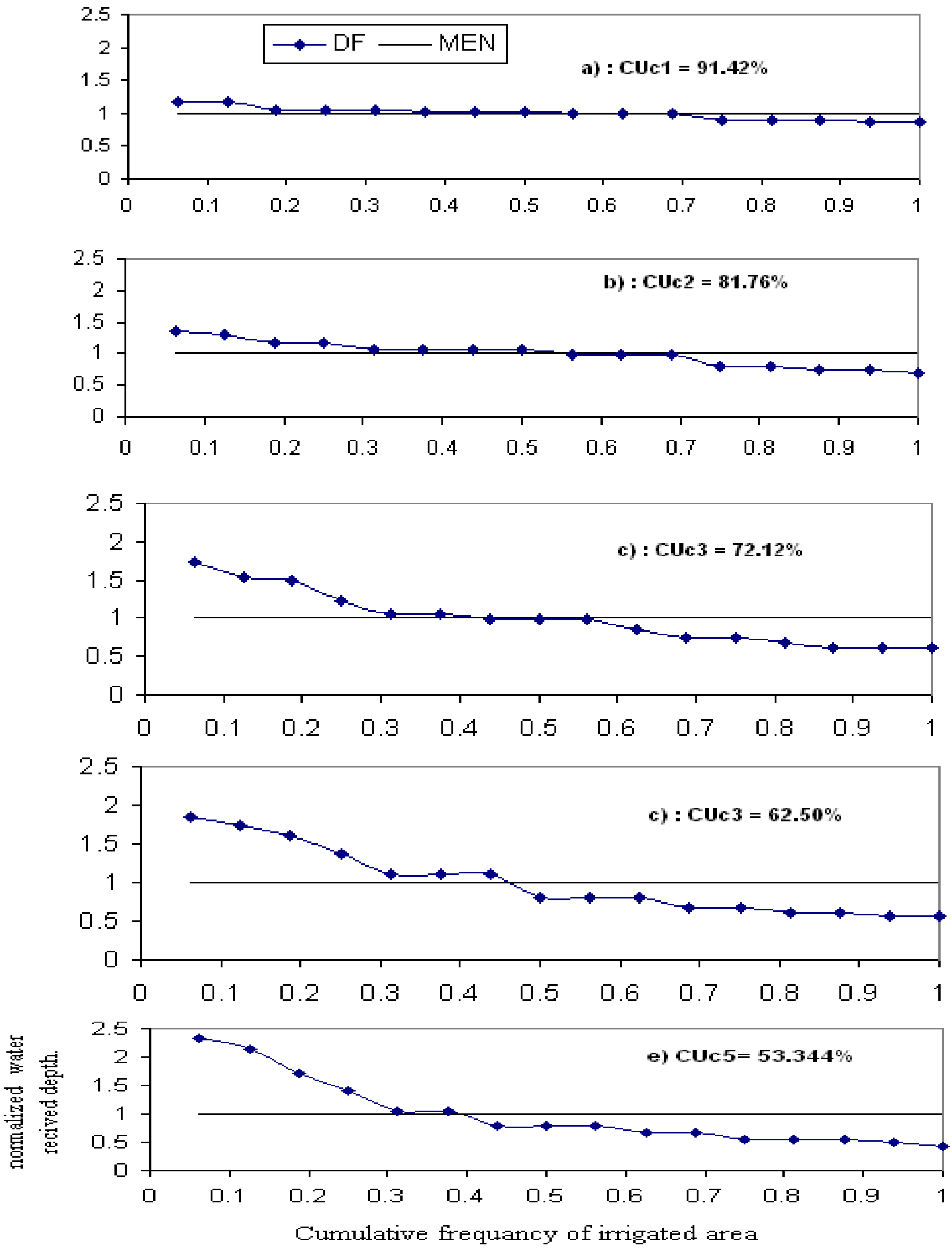

Fig.(1): cumulative frequance of water distribution pattern for five levels of irrigation water uniformity

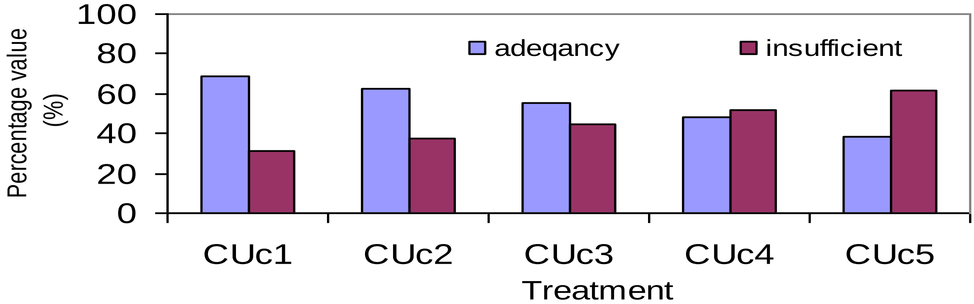

Fig. (2): Effect of irrigation uniformity coefficienty on irrigation adequency and insufficient of irrigation

5. **Effect of irrigation uniformity coefficient on water losses by deep percolation**.

Fig.(3) illustrates the percentage of water losses by deep percolation under 60 cm depth for the five treatments. The results indicated that irrigation uniformity coefficient had high significant effect on water losses by deep percolation. By decreasing irrigation uniformity coefficient water losses by deep percolation increased. It reached a maximum value 23.04% for treatment CUc5, while the minimum value 3.24% obtained at treatment CUc1. By decreasing the irrigation uniformity coefficient, the depths of received water for some subplots were increased. Greater irrigation depth over 49 mm allowed water to move more than 60 cm beyond wheat root zone causing big water losses by deep percolation. So, decreasing the irrigation uniformity coefficient caused high percentage losses of irrigation water by deep percolation, while increasing irrigation uniformity coefficient reduced water losses and keep it within the reach of wheat root zone. The relationship between percentage of water losses by deep percolation and irrigation uniformity coefficient was found to be a linear relation and obtained in equation (7).

$$Dp = (-0.5378 * CUc) + 52.26 \qquad \text{Eq. (7)}$$

$R^2 = 0.9987$

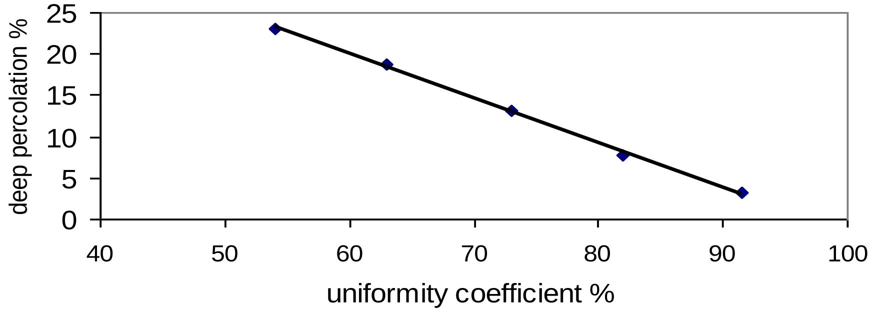

Fig.(3): Effect of irrigation uniformity coefficient on water losses by deep percolation

6.Effect of seasonal water depth on wheat crop length, grain yield and water use efficiency.

To investigate variations in crop height, grain yield and water use efficiency as a function of irrigation management reflected in the water distribution, the indices were determined for each of the 16 subplots in the main plots. Fig. (4) shows crop height , grain yield and water use efficiency as a function of seasonal received water depth. First two parameters were increasingly affected by the seasonal received water to 815 mm depth. Crop height and production reached their maximum values 68cm and 5.8 $t.ha^{-1}$ at a seasonal water depth of 821 and 815 mm, respectively. While, the water use efficiency curve exhibits a negative correlation and the results indicate that a reduced seasonal water depth increases the water use efficiency of wheat crop. Water use efficiency reached its maximum value (1.098 kg m^{-3}) at a seasonal water depth of 305 mm. By increasing the seasonal water depth crop height and grain yield increased, while water use efficiency decreased. Regarding the regression analysis, a quadratic relationship was observed between three parameters and the seasonal received water depth and shown in the figure.

Data presented in (table 6) show the effect of irrigation uniformity coefficient on crop height, grain yield and water use efficiency. The mean values of three parameters were significantly increased by increasing irrigation uniformity coefficient. The treatments CUc1 and CUc2 recorded the highest values of crop height, grain yield and water use efficiency with significant differences with other treatments. Meanwhile treatment CUc5 had the lowest values for all previous parameters. The treatments CUc1 had the highest values of crop height, grain yield and water use efficiency 59.25 cm, 4.57 $t.ha^{-1}$ and 0.76 $kg.m^{-3}$, respectively with insignificant differences with treatment CUc2. While the lowest values of crop height, grain yield and water use efficiency 55.10 cm, 4.10 $t.ha^{-1}$ and 0.68 $kg.m^{-3}$, respectively.

7.Effect of irrigation uniformity coefficient on Christiansen uniformity coefficients for wheat crop height, grain yield and water use efficiency.

Fig. (5) shows the Christiansen uniformity coefficients for wheat crop height, grain yield and water use efficiency as a function of irrigation uniformity coefficient. Analysis of the linear relationships reveals a greater dependency of water use efficiency on irrigation uniformity compare to crop height and grain yield. Christiansen uniformity coefficients ranged from 95 to 98% for crop height, from 85 to 95% for grain yield and from 73 to 87% during the irrigation season. The study indicated that the CUc values for crop height, grain yield and water use efficiency of wheat crop were higher than the CUc values for sprinkler irrigation uniformity coefficient during the irrigation season. Li and Rao (2000) reported a similar result for winter wheat.

The findings illustrate that the uniformity coefficient of sprinkler irrigation systems has a direct effect on wheat growth, grain yield and water use efficiency. However, high grain yield uniformity does not automatically mean high grain yield. Wheat grain yield depends on both the applied water depth and the sprinkler irrigation uniformity but it is more sensitive to the variations in applied water depth than to the variations in sprinkler irrigation uniformity. Hence, in rain-fed agriculture as well as in deficit irrigation, a high uniformity of yields with undesirable low yields may be found, while highly uniform over-irrigation would be a waste of water. Grain yield is affected by the available water storage and the soil water stress of the root zone (as a result of sprinkler water uniformity). It should be recommended to reduce the water application of wheat crop and to improve sprinkler irrigation uniformity coefficient in arid and semi-arid regions.

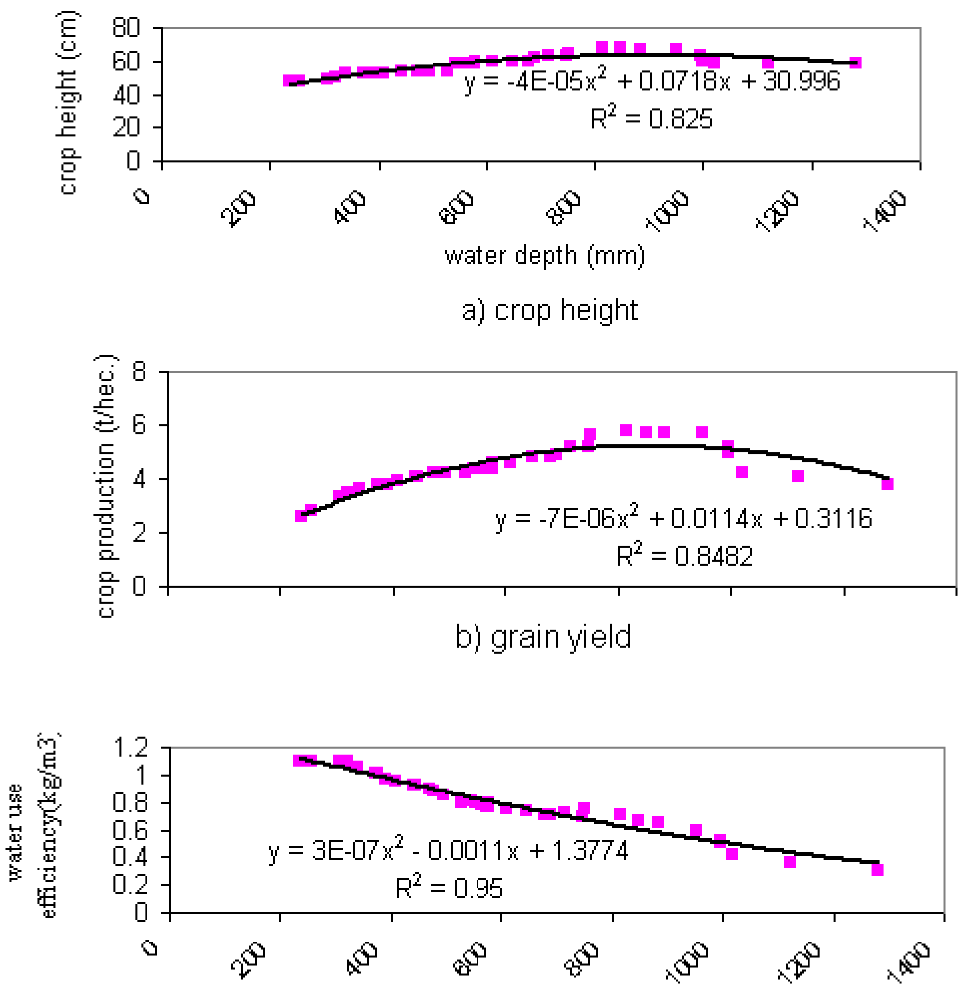

Fig.(4): Effect of sesonal water depth on wheat crop height, grain yield and water use efficiency .

Table (6): Average values of height, grain yield and water use efficiency.

Parameters	Treatments				
	CUc 1	CUc 2	CUc 3	CUc 4	CUc 5
Height (cm)	59.25a	59.10a	57.10b	55.30c	55.10d
Grain yield ($t.ha^{-1}$)	4.68a	4.53a	4.43b	4.20c	4.10d
WUE ($kg.m^{-3}$)	0.78a	0.75a	0.74b	0.70c	0.68d

the same latter at the same row are not statistically different at *P<0.05* level according to Duncan's Multiple Range Test.

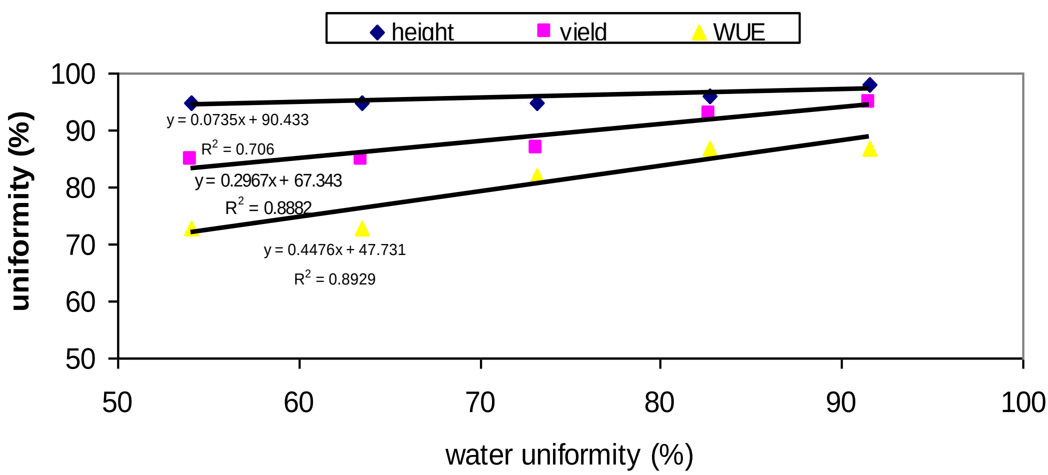

Fig.(5): Christiansen uniformity coefficient for crop height, yield and WUE as a function of sprinkler water uniformity,

CONCLUSION

The purpose of this research work is to explore the effect of sprinkler irrigation uniformity coefficient on wheat crop height, grain yield, water use efficiency, water losses by deep percolation and irrigation adequacy through field experiments. Also, to study its effect on Christiansen uniformity coefficient values of crop height, grain yield and water use efficiency. The other purpose is to obtain the response of wheat growth and grain yield to seasonal applied water depth. Treatments consisted of five different sprinkler irrigation uniformity values: "CUc1" (>90- <95%), "CUc2" (>80- <85%),"CUc3" (>70- <75%), "CUc4" (>60- <65%) and "CUc5" (>50- <55%).

The results indicated that:

1. Irrigation tests were carried out under conditions of relative humidity ranged from 50 to 68%, air temperature ranged from 16 to 30 ^{o}c and wind speed ranged from 4.1 to 4.8 km.h^{-1} . The mean values of measured irrigation uniformity were 91.42, 81.76, 72.12, 62.50 and 53.3% for treatments CUc1, CUc2, CUc3, CUc4 and CUc5
2. Percentage of water losses by evaporation "EL" were varied as weather conditions varied. Air temperatures "T" had the highest effect on water losses by evaporation then the relative humidity "RH", while wind speed "W" had the lowest effect on it.

   EL = -3.831 + 0.0213*W+ 0.07987*RH + 0.454*T
3. The maximum value of irrigation adequacy was 68.5% for treatment CUc1, while the minimum value was 38% for treatment CUc5. By increasing irrigation uniformity coefficient the irrigation adequacy increased while irrigation insufficient decreased.
4. The maximum value of water losses percentage by deep percolation was 23.04 % for treatment CUc5, while the minimum value was 3.24% for treatment By decreasing the irrigation uniformity coefficient "CUc" caused high losses of irrigation water by deep percolation "Dp". The relationship between "Dp" and "CUc" was found to be a linear relation.

   Dp = (-0.5378*CUc) + 52.26
5. By increasing the seasonal water depth to 815mm, crop height and grain yield increased and reached to their maximum values 68cm and 5.8 T.ha^{-1} respectively. The water use efficiency increased by decreasing the seasonal water depth and reached to its maximum values 1.098 kg.m^{-3} at seasonal water depth 305mm.
6. The treatments CUc1 had the highest values of crop height, grain yield and water use efficiency 59.25cm, 4.57t.ha-1 and 0.76kg.m^{-3},

respectively with insignificant differences with treatment CUc2. While the lowest values of crop height, grain yield and water use efficiency 55.10 cm, 4.10 $t.ha^{-1}$ and 0.68 $kg.m^{-3}$, respectively for treatment CUc5.

7. Christiansen uniformity coefficients ranged from 95 to 98% for crop height, from 85 to 95% for grain yield and from 73 to 87% for sprinkler irrigation uniformity coefficient ranged from 53.30 to 91.42% .Christiansen uniformity coefficient values for crop height, grain yield and water use efficiency of wheat crop were higher than the "CUc" values for sprinkler irrigation uniformity coefficient during the irrigation season.

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الملخص العربي

تأثير انتظامية الري بالرش على إنتاجية القمح وفواقد المياه وكفاءة استخدام المياه

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أجريت هذه الدراسة الحقلية بمحطة التجارب الزراعية والبيطرية بكلية الزراعة والطب البيطري - جامعة القصيم. خلال موسم٢٠٠٧ /٢٠٠٨ م وذلك لدراسة تأثير معامل الانتظامية لنظام الري بالرش على كل من طول النبات ومحصول الحبوب وكفاءة الاستخدام المائي للقمح صنف **يوكورا** وكذلك تأثيره على معامل الانتظامية للمؤشرات الثلاثة السابقة وكفاية الري وفقد المياه بالتسرب العميق. كما يهدف البحث إلى دراسة بيان مدي استجابة إنتاجية القمح لكمية مياه الري المضافة خلال موسم النمو. ولتحقيق أهداف هذه الدراسة تم استخدام خمس معاملات ذات قيم مختلفة لمعامل انتظامية الري بالرش. وكانت المعاملات المستخدمة هي: "CUc1" (<٩٠- >٩٥٪), "CUc2" (<٨٠- >٨٥٪),"CUc3" (<٧٠- >٧٥٪), "CUc4" (<٦٠- >٦٥٪), "CUc5" (<٥٠- >٥٥٪).

وقد أظهرت الدراسة ما يلي:-

١. تراوحت قيم النسبة المئوية للرطوبة الجوية أثناء تجارب الري بالرش من ٥٠-٦٨٪ ودرجة الحرارة من ١٦ - ٣٠ درجة مئوية وسرعة الرياح من ٤,١- ٤,٨ كم/ساعة. وكانت القيم المتوسطة لمعامل الانتظامية للري بالرش خلال موسم النمو ٩١,٤٢ و٨١,٧٦ و ٧٢,١٢ و ٦٢,٥٠ و٥٣,٣٠ % للمعاملات CUc1, CUc2, CUc3, CUc4, CUc5 على الترتيب.

٢. تختلف النسبة المئوية للمياه المفقودة بالبخر أثناء الري باختلاف العوامل الجوية (درجة الحرارة- نسبة الرطوبة الجوية- سرعة الرياح). ووجد أن درجات الحرارة "T" أكثر العوامل تأثيرا في فقد المياه بالبخر ثم الرطوبة النسبية "RH" بينما كانت سرعة الرياح "W" اقل العوامل الجوية تأثيرا على فقد المياه بالبخر. وقد تم استنتاج معادلة رياضية تربط بين النسبة المئوية للمياه المفقودة بالبخر"EL" و الظروف الجوية أثناء الري.

$$EL = -3.831 + 0.0213*W + 0.07987*RH + 0.454*T$$

٣. تحققت أعلى قيمة لكفاية الري للمعاملة "CUc1" ٦٨,٥٪ , بينما اقل قيمة كانت ٣١,٥٪ للمعاملة " CUc5". تزداد قيمة كفاية الري وتقل المساحة التي تعاني من نقص الري بزيادة معامل الانتظامية للري بالرش.

٤. تحققت أعلى نسبة مئوية لفقد المياه بالتسرب العميق للمعاملة "CUc5" ٢٣,٠٤٪ , بينما اقل نسبة مئوية لفقد المياه بالتسرب العميق كانت ٣,٢٤ % للمعاملة " CUc1" . يزداد فقد المياه بالتسرب العميق بنقص معامل الانتظامية للري بالرش, وقد وجد أن النسبة المئوية لفقد المياه بالتسرب العميق "Dp" ترتبط بعلاقة خطية مع قيم معامل الانتظامية للري بالرش "CUc".

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$$Dp = (-0.5378*CUc) + 52.26$$

٥. يزداد كل من طول النبات ومحصول الحبوب للقمح بزيادة كمية مياه الري المضافة خلال الموسم, حيث وصلا إلى أعلى قيمة لهما ٦٨سم, ٥,٨ طن/هكتار على الترتيب عند إضافة ٨١٥مم /الموسم. بينما تزداد كفاءة الاستخدام المائي بنقص كمية مياه الري المضافة خلال الموسم, حيث وصل إلى أعلى قيمة له ١,٠٩٨ كجم/م٣ عند إضافة ٣٠٥مم /الموسم.

٦. أعلى قيم لكل من طول النبات ومحصول الحبوب وكفاءة الاستخدام المائي للقمح كانت ٥٩,٥ سم و ٤,٥٧ طن/هكتار ,٠,٧٦كجم/م٣ على الترتيب للمعاملة "CUc1" بدون أي فروق معنوية عن المعاملة "CUc2" ,بينما كانت اقل قيم لهذه المؤشرات ٥٥,١سم و ٤,١ طن/هكتار و ٠,٦٨كجم/م٣ للمعاملة "CUc5"

٧. معامل الانتظامية لكل من طول النبات ومحصول الحبوب وكفاءة الاستخدام المائي للقمح أعلى من معامل الانتظامية للري بالرش, حيث تراوح معامل الانتظامية لطول النبات من ٩٥-٩٨٪ ولمحصول الحبوب من ٨٥-٩٥٪ ولكفاءة الاستخدام المائي من ٧٣-٨٧٪ وذلك لنظم ري بالرش معامل الانتظامية لها يتراوح من ٥٣,٣٪ - ٩١,٤٢٪.