MANAGEMENT OF SPRINKLER IRRIGATION SYSTEM FOR CUMIN IN OLD VALLEY

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Abstract

This investigation was carried out at private farm in El Gharbeia Governorate during seasons 2009 /2010 and 2010 /2011 to study the effects of two irrigation systems (surface and sprinkler) under three irrigation levels of 0. 6 , 0.8 and 1.0 from the ETc on applied irrigation water , yield and yield components for cumin. Data show the values of Kc during different stages .Kc increased from initial stage   to mid-season then decreased to harvest stage Water applied values were 28 , 48 , 68 , 40,and 20 mm   for   initial , development , mid-season , late and harvest stages respectively. Data indicated that , using sprinkler irrigation system reduced the applied of amounts of irrigation water by 47.85 and 45.50 % in the two growing seasons comparing with surface irrigation. Meanwhile, yield increased by about 10.16 and 12.52 % under sprinkler system irrigation comparing with surface irrigation in first and second growing seasons respectively . While decrease water use efficiency under surface irrigation by 52.7 and 53.6% comparing with sprinkler irrigation in two seasons respectively . On the other hand as water as decreased from 1.0 to 0.8 and 0.6 from ETc (evapotranspiration), Cumin yield decreased by 14.05 and 14.25 and by 25.6 and 26.89 % in the two seasons respectively . Also , water use efficiency increased by 5.26 , 19.30 , 10.17 and 16.9 %   in two seasons comparing by 1.0 ETc respectively .

Keywords : cumin, sprinkler irrigation, crop evapotranpriation

INTRODUCTION

Cumin is a cash crop with a short growing cycle. which demands little moisture and nutrient inputs . Generally cumin crop takes about 110 – 120 days. The amount of irrigation water applied to the field are determined by how are irrigation systems and scheduling managed. Greater amounts are applied with surface irrigation more than with sprinkler irrigation system. The irrigation system delivers and distributes the water , but the produced crops consume the amount of needed water . Growers invest in better irrigation systems that enable more uniform water application and improve management of the amount applied.

Awady *et al*. (2003), working on pup-up sprinklers used in turf grass, studied water distribution uniformity in individual and grouping tests. Water was

collected using catch cans for individual sprinkler heads of different types in x-y and radial directions. Results taken in x-y direction were fitted against those from radial. They also correlated between distribution uniformity determined from data in x-y directions against those collected along laterals in triangular sprinkler heads layout . A high correlation among results was found . They also found how grass growth was affected by non- uniformity of irrigation application by sprinkler system.

Keller and Bliesner (1990) stated that most sprinkler irrigation systems require a minimum value of water distribution uniformity {Christiansen,s coefficient of uniformity CU > 80 %}. Low values of CU are usually indicators of a faulty combination of the number and size of nozzles, working pressure and spacing of sprinklers.

Tarjuelo *et al.* (1999) stated that the process of water application in Solid-Set sprinkler systems mainly depends on the following factors:1- sprinkler water distribution pattern, the sprinkler design, the number and type   of nozzles and the working pressure.
2- sprinkler layout, which refers to the spacing between sprinklers and 3- wind speed and direction.

Merriam and Keller (1978) stated that the procedure to determine sprinkler water distribution can be grouped into two types:1- apply the catch can grid to the existing irrigation system, evaluation of the system and 2- place a catch can grid around a single

Bondok and El-Sharkawy (2008) conadcted experimental work during 2007 to study and to evaluate sprinkler irrigation system in order to improve efficiencies and management of system on cotton crop. The experimental work and data collecting on irrigation practice and operational condition were carried out in Gemmeza Research Station Gharbia Governorate. The results reveal that by using Bondok computer program in evaluating sprinkler system. Increased both average low quarter 21.5%, individual sprinkler discharge 11.11%, Distribution Uniformity (DU) % , Coefficient of Uniformity (CU) %, Potential Application Efficiency of Low Quarter (PELQ) % and Application Efficiency (AE) % by 22.1, 9.1, 8.9, 9.5 respectively. Nevertheless Efficiency Reduction (ER) decreased by 21.0 %. Due to use, of sprinkler irrigation system, the yield decreased by 10.2 %. Nevertheless , due to sprinkler irrigation system use the water use efficiency increased by 75%. The data show that by using sprinkler irrigation system , the amount of water saved increased by 50.9%. While *Arnaout (1995)* stated that the efficiency of any irrigation system depends on water supply in the desired time. The average irrigation efficiency of the drip irrigation system increased by about 15.87 and 38.37 % more than irrigation efficiency of sprinkler and furrow systems respectively. *EL-Yazal et al. (1998)* indicated that sprinkler irrigation system saved 17.81 % of water applied and increased the yield by

22.6 %compared to surface irrigation. The water utilization efficiency increased by 51% in sprinkler compared to surface irrigation system.. El-Gindy and Abdel-Aziz (2003) studied the effects of irrigation method (drip and sprinkler) rate (50 , 75, and 100% water consumptive use) and interval (irrigation daily and irrigation at three-day intervals) on maize water use efficiency and yield . They found that higher grain yields were obtained with drip irrigation than with sprinkler irrigation . Irrigation daily gave higher yields than irrigation at three-day intervals .

      Joseph *(1995)* stated that crop response to water is a continuous function. In practice, there is no clear cut demarcation   indicating when water requirement ends and leaching begins. The leaching requirement (LR) relates to an amount of water applied above the consumptive use requirement (CR) of a crop in order to facilitate the removal of accumulated salts. It is generally difficult to avoid deep percolation under normal field irrigation.

      The objectives of this study were to management and evaluation of the sprinkler irrigation system for Cumin under different levels from ETc on irrigation water , yield and water use efficiency.

MATERIALS AND METHODS

      An experiment was conducted to determine the effect of some irrigation systems as traditional and sprinkler irrigation , and irrigation level treatments as 0.6 ETc , 0.8 Etc and 1.0 ETc (ETc is crop evapotranspiration) . The field experiments were performed at private farm in El Gharbeia Governorate during 2009/2010 and 2010 /2011 seasons . All treatments were randomized in three replicates . Physical andl mechanical analyses of the soil were determined according to Black (1965) in Table (1) Chemical analysis of irrigation water experimental field presented in table 12

Table 1. Mechanical analysis and some soil moisture contents of the studied soil experimental.

Depth cm	Fine sand%	Coarse sand%	Silt%	Clay%	Soil texture	FC.%	W.P.%
0-20	3.00	20.70	27.00	49.30	Clay	42.10	21.30
20-40	3.85	20.65	27.10	48.40	Clay	42.60	20.50
40-60	3.95	20.40	28.20	47.45	Clay	43.70	21.90
60-80	4.45	20.45	28.20	46.90	Clay	44.40	22.50

Table 2. Chemical analysis values of irrigation water experimental filed.

ECdS/m	Soluble cations,meq/l				Soluble anions,meq/l				SAR
	Ca	Mg	Na	K	Co 3	Hco 3	So4	Cl	
1.34	5.44	6.53	5.9	0.1	0.85	3.9	6.0	7.9	2.8

Average ETo calculated according to the data recorded by Kator weather station , El Gharbeia Governorate which is affiliated to the Central Laboratory for Agricultural Climate ,Ministry of Agriculture and Land Reclamation .

Table 3. ETo mm/day for the location of Kator

Month	Nof	Des	Jan	Fe	Mar
Eto	2.75	2	1.8	2.1	3.25

Seeds of Cumin were sown on Nov. 15 and 20 at 1st and 2nd seasons, respectively ,in hills , 25 cm. apart within rows 60 cm in between . All of the recommended agronomic practices were followed for cumin production in the region . Harvesting was on March for two seasons.

Traditional irrigation :

The irrigation water was supplied to the border surface irrigation through a circular orifice of 10 cm diameter and its discharge rate was measured by using the equation of James (1988) as follows :

$$Q = 0.61 \ KAH^{1/2} \qquad\qquad 1$$

Where,

Q = orifice discharge ,l/s

A = the area of orifice opening ,cm^2

H = head, m

K = unit constant. (K = 0.443 for Q in l/s, A in cm^2, and H in m)

Sprinkler system

The system had portable mainlines, sub mains, laterals, portable pumping plant, Single nozzle sprinkler 3 mm in diameter and 0.6m^3 /h discharge made by (NAN). Fig .1 shows layout of sprinkler irrigation system. Fig. 2 shows evaluation of sprinkler irrigation system.
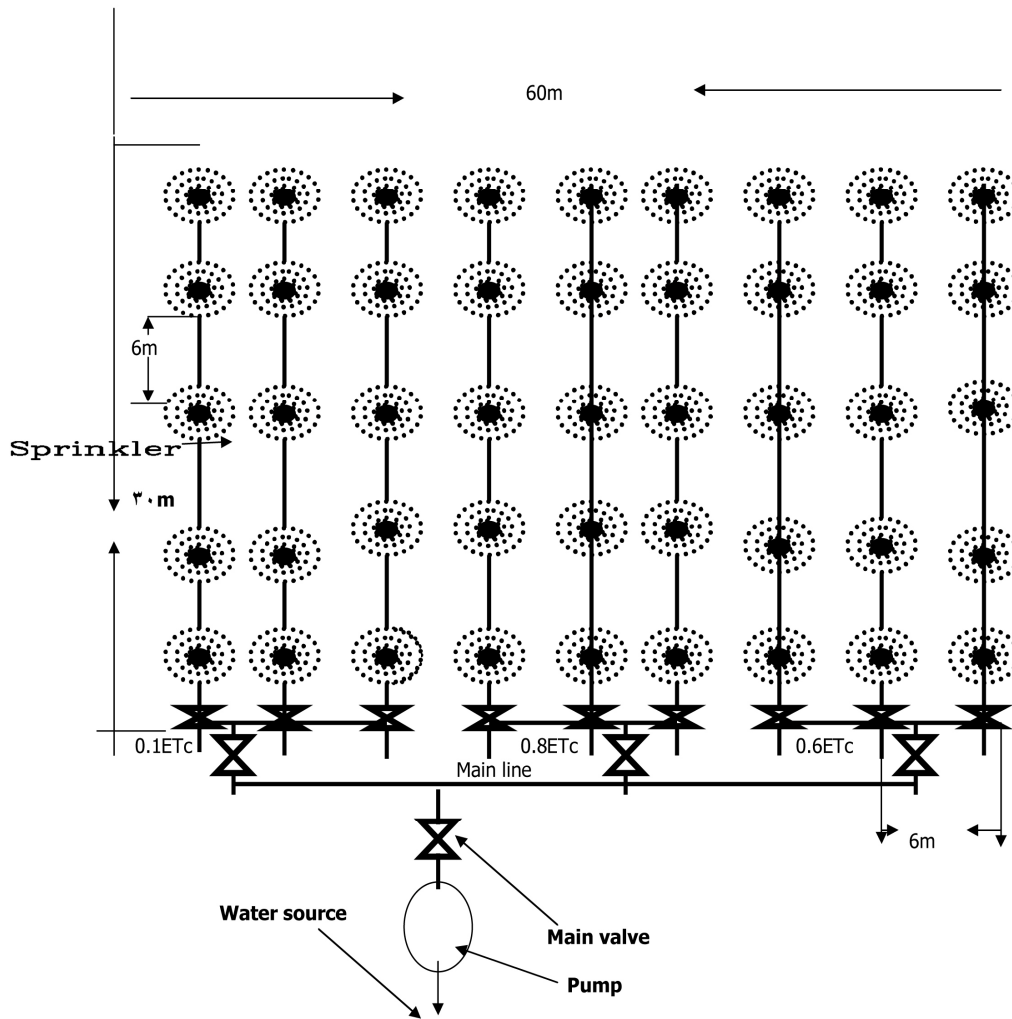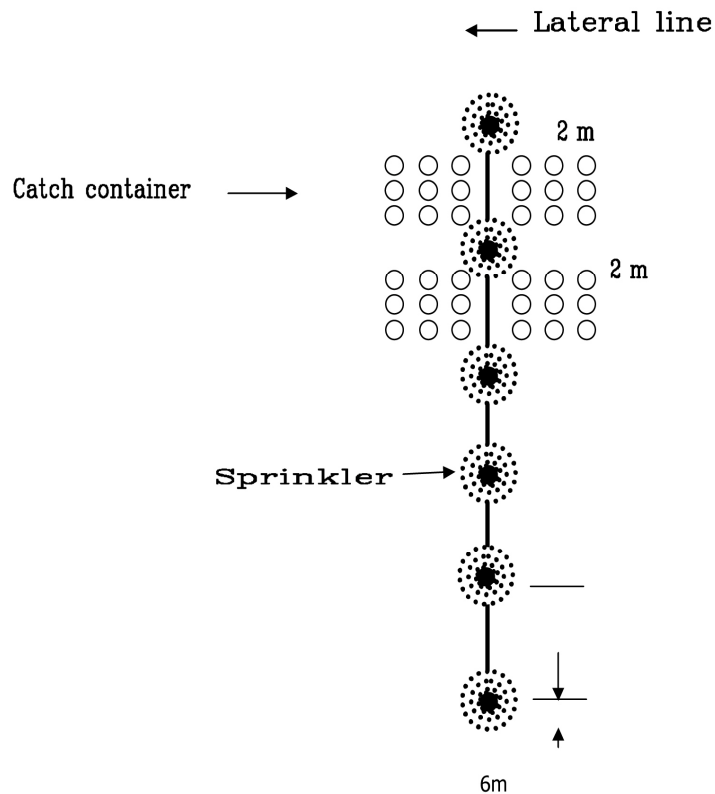
Fig. 1. layout of sprinkler irrigation system.

Fig. 2. Evaluation of sprinkler irrigation system.

Equipment:

1) Pressure gauge: (0-6) bar with pitot attachment.

2) Stopwatch: with an accuracy of 0.01 second was used to determined different times of the experiments.

3) Large container: of known volume clearly marked.

4) 2 -m length of flexible hose having diameter appreciably larger than the outside diameter of nozzles.

5) sixty catch cans .

6) 500-ml graduated cylinder to measure volume of catching water in cans.

 Measurements:

1) Spacing between sprinklers along lateral line.

2) Spacing between lateral lines along the main line.

3) Measuring depths of water caught in catch cans.

4) Duration of the test.

5) Water pressure at the sprinkler nozzles.

6) Rate of flow from the tested sprinklers.

Calculation:

Irrigation uniformity and efficiencies for the system were calculated according to Merriam and keller (1978) (using bondok computer program. 2006)

Leaching requirement

Leaching requirement (LR) is the minimum amount of irrigation water supplied that must be drained through the root zone to control soil salinity at the given specific level. The leaching requirement was estimated according to Doorenbos and Pruitt, (1977) for surface irrigation methods by the following equation.

$$LR = \frac{ECw}{5\,ECe - Ecw} \qquad (1)$$

where:

ECw = electrical conductivity of irrigation water, dS/m.

ECe   = electrical conductivity of the soil saturation extract dS/m.

 Moisture content:

Water holding capacity (W.H.C) mm :

W.H.C = (FC % - PWP %) ×bulk density ,$g.cm^{-3}$ × root zone,cm × 10

Where:

FC is field capacity.

PWP is permanent wilting point·

Maximum net water requirement (Max - n.w .r) mm.

Max. n . w. r   =   MAD   × W.H.C ÷ 100

MAD   management allowable deficit mm/ m

Maximum gross water requirement (max. g.w.r) mm

Max.g.w.r. = max.n.w.r. × 100 ÷ AE

AE :   Application efficiency , %

Irrigation interval II (day)

II = max-n.w.r. ÷   ETc

Time for irrigation , TIR (h)

TIR=   Max-g.w.r. ÷ infiltration rate, mmh^{-1}

 Infiltration rate of the soil were determined in the field using double ring
 (cylinder infiltrometer)

Crop coefficient

Kc = Etc / ETo

where

Kc   =   is crop coefficient

ETc   = actual crop evapotranspiration ,mm

ETo   =   Reference evapotranspiration ,mm

Yield:

Harvesting should be done, when plants are yellowish brown by cutting the whole plants and separate the seeds, and computed the yield kg / fed.

Water Use Efficiency (WUE):

WUE = {Average yield, kg /Fed} /{Applied water, m^3/fed } **=** kg/m^3(Michael,1978).

RESULTS AND DISCUSSION

Crop coefficient (Kc)

The factors affecting on the value of the crop coefficient Kc (where Kc = Etc /Eto) are mainly the crop characteristics ,sowing date ,rate of crop development , length of growing season . The average values of Kc for cumin in different stages is shown in   .Fig. (3). The values increased from initial , development to mid-season then decreased in late and harvest stages . Initial stage Kc was 0.35,at development stage was 0.75 , and mid-season stage was 1.0, for the late season stage it was 0.7 and for the harvest stage it was 0.5 .The same trend was found in the second season where the values were 0.30 , 0.7 ,1.00, 0.6 and 0.45 for the initial ,development ,mid season ,late season and harvest stages respectively .
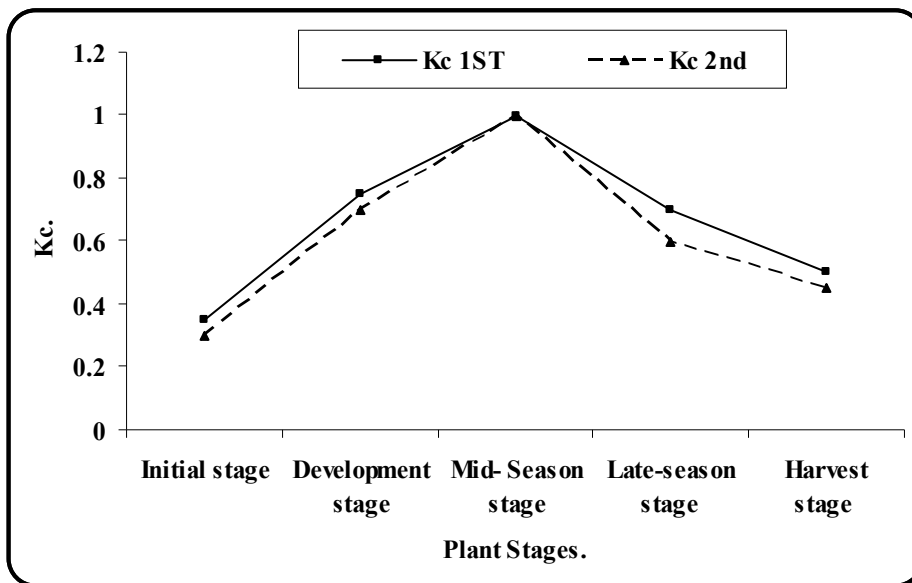

Fig. 3. Seasonal evaluation of Kc during cumin growth stages .

System Evaluation

Data in Table (4) show the sprinkler irrigation system evaluation of distribution uniformity (DU) %,coefficient of uniformity% ,average water application (R)mm/h, potential application efficiency of low quarter (PELQ) % ,application efficiency %, system efficiency %,system coefficient of uniformity(SCU) %, system distribution uniformity (SDU) ,field water use efficiency (F W U E) kg/ m^3 .The values in Table (4) are 75 , 80 12.5, 78.4,2.66 , 74 , 95 ,82, 77and 70 % for distribution uniformity (DU)   %,coefficient of uniformity% ,average of water application (R)mm/h, potential application efficiency of low quarter (PELQ) % ,application efficiency %, system efficiency %,system coefficient uniformity(SCU) % %,and system distribution uniformity (SDU)respectively.

Table 4. Sprinkler irrigation efficiency.

1	Site	AL-Gharbeia
2	Crop.	Cumin
3	Distribution Uniformity (DU) %	75
4	Coefficient of uniformity (CU) %	80
5	Average rate of water application (R) mm/h.	12.5
6	Potential application Efficiency of leastQuarter (PELQ) %	78.4
7	Efficiency Reduction (ER) %	2.66
8	System Potential Application Efficiency of least Quarter% (SPELQ)	74
9	Application efficiency (AE) %	95
10	System Efficiency (SE) %	82
11	System Coefficient Uniformity (S CU) %.	77
12	System Distribution Uniformity (S DU) %.	70

Water applied during different stages under sprinkler irrigation .

Data in Table (5) show the average of water applied during different stages mm/period for cumin in two seasons . Water applied in the initial stage was 28 mm for 25 days , in the development stage was 48 mm for 30 day ,in the mid season had the highest value of 68mm for 30 days .Then water application decreased in late season to 40 mm for 20 days and in the harvest stage it was 20 for 10 days .

Data in Table (5) show the average water applied during different stages in two seasons (initial, development ,mid , late and harvest)under sprinkler irrigation .Water applied increased from initial to development stages and the maximum water applied was in mid season   then decreased in late and harvest stages under all levels of irrigation. The highest values in all stages under 1.0 ET, were 117.6, 201.6 , 285.6 ,

168.0 and 84   m^3/Fed recp. . Under 0 .8 ETc,the values decreased to 94.00 , 161.28 , 228.48, 134.4and 67,2 m^3/fed..Meanwhile the lowest values under 0.6 ETc. were 70.56 120.36, 171.36, 100.8 and 50.4 m^3/fed.for initial, development ,mid ,late and harvest stages ,respectively.

Table 5. Sprinkler irrigation depth for cumin crop during stages for growing season.

Stages	Initial	Development	Mid-season	Late season	Harvest	Total
day Period	25	30	30	20	10	115
Water applied mm/Period	28	48	68	40	20	204
L.R m^3/fed.						128.5
Rain m^3/fed.	36			63		72
Water applied 1.0ETc m^3/fed.	117.6	201.6	285.6	168	84	1057.3
Water applied 0.8ETc m^3/fed.	94.00	161.28	228.48	134.4	67.2	860.36
Water applied 0.6ETc m^3/Fed.	70.56	120.36	171.36	100.8	50.4	662.58

Irrigation water.

Irrigation water for Cumin and saving under some different irrigation systems (Sprinkler and traditional irrigation systems) and sprinkler irrigation level treatments as 0.6 , 0.8 and 1.0 of ETc was crop evapotranspiration

Effect of irrigation systems

Data in Table (6) indicate that the irrigation water applied for Cumin was reduced by 47.85 and 45.50 % using sprinkler   irrigation comparing with traditional irrigation in the first and second seasons.

Table 6. The effect of surface and sprinkler irrigation systems on average cumin yield
and water use efficiency.

Seasons	Irrigation systems	Average yield kg/fed.	Amount of water m^3/fed.	Water use efficiency kg/m^3
1st	Sprinkler	525	860.25	0.62
	Surface irrigation.	476.6	1650	0.29
2nd	Sprinkler irrigation.	520	820.24	0.65
	Surface irrigation.	456.2	1505	0.30

Effect of sprinkler irrigation levels .

Data in Table (7) show sprinkler irrigation levels for 0.6 , 0.8 and 1.0 ETc.
.We found that the amount of water decreased from 1057.8 to 860.36 and 662.58
m^3/fed.under 1.0 , 0.8 and 0.6   ETc. respectively . The same trend in the second
season . The values were 1007.3, 820.24and 633.18 m^3/fed.respectively .

Table 7. The effect of sprinkler irrigation levels on average cumin yield and
water use efficiency.

Seasons	Irrigation system	Irrigation treatments	Average yield kg/fed.	Amount ofwater m^3/fed	Wateruse efficiency kg/m^3
1st	Sprinkler irr igation.	1.0 Etc	605	1057.8	0.57
		0.8 Etc	520	860.36	0.60
		0.6 Etc	450	662.58	0.68
2nd	Sprinkler irrigation.	1.0 Etc	595	1007.3	0.59
		0.8 Etc	530	820.24	0.65
		0.6 Etc	435	633.18	0.69

Yield

Effect of irrigation systems

Fig.4 shows the effect of some irrigation systems on cumin yield .Yield increased
by10.16 and 12.52 % under sprinkler system irrigation comparing by traditional
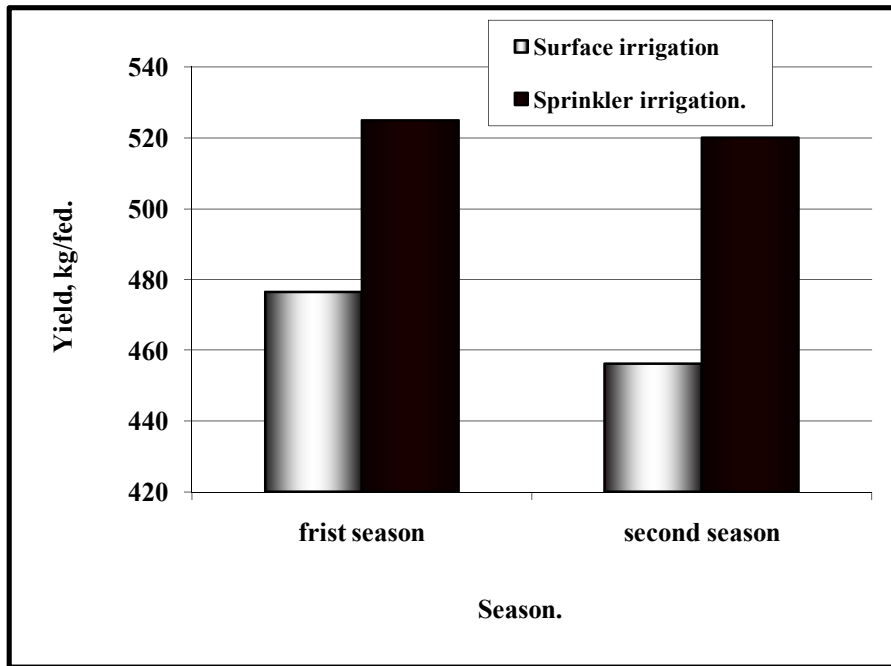irrigation in the first and second seasons .

Fig. 4 . Effect of irrigation system on cumin yield .

Sprinkler irrigation levels.

Fig. 5   shows that the relation between yield and water deficit is inverse. Cumin yield decreased in linear relationship as water deficit increased under sprinkler system .Data show that , yield decrease by 14.05 and   25.6 %under irrigations with 0.8 and 0.6 ETc compared by 1.0 ETc. In second the season ,the ratios of decrease were 14.29 and 26.89 %under 0.8 and 0.6 ET compared by 1.0 ETc .
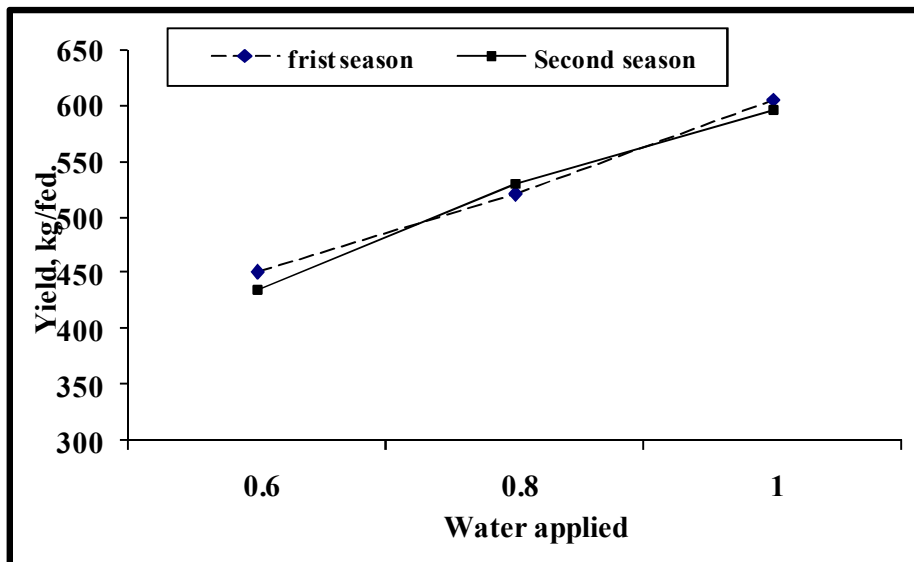
Fig. 5. Effect of water deficit on cumin yield .

Water use efficiency (W U E)

Irrigation system

Fig. 6 shows decreased water use efficiency under traditional irrigation by 52.7% compared by sprinkler irrigation The same trend was noticed in second season decrease with 53.6 %.
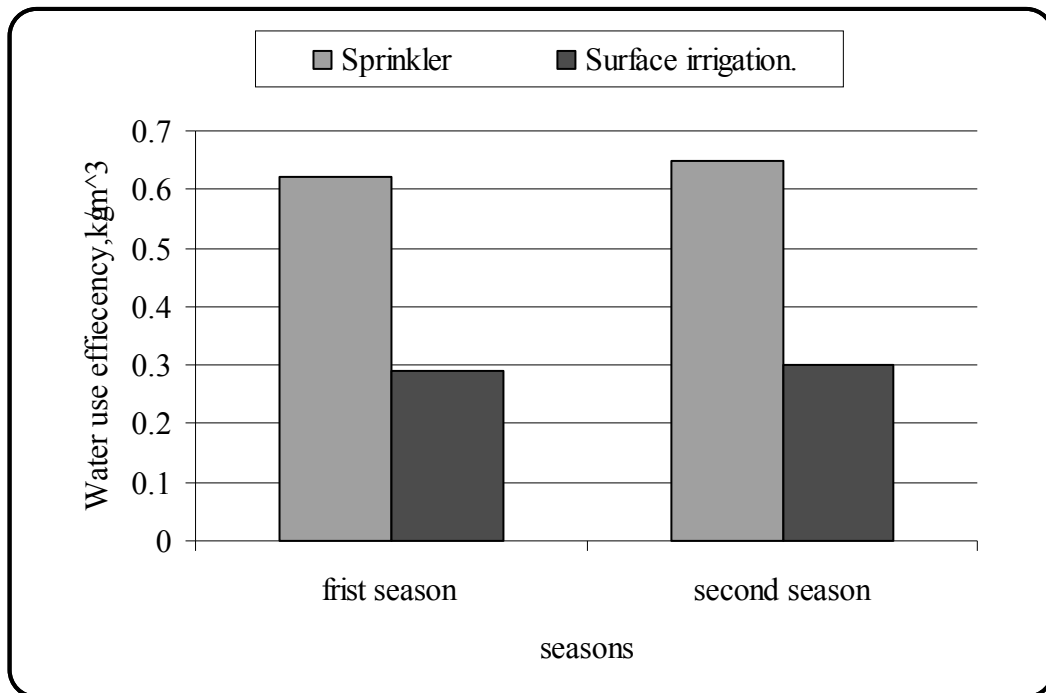
Fig. 6 . Effect of irrigation system on water use efficiency for Cumin crop.

Sprinkler irrigation level

Fig. 7 . shows that ,the highest value was by using level 0.6 ETc. It was 0.68 kg/m3 . The lowest value was 0.57 kg /m3 by using 1.0 ETc applied . The value was 0.60 kg /m3 by using 0.8 ET water . The second season data took the same trend by values of 0.59 , 0.65 and 0.69 kg/ m^3 by using 1.0 ,0.8 and 0.6 ETc applied water respectively .
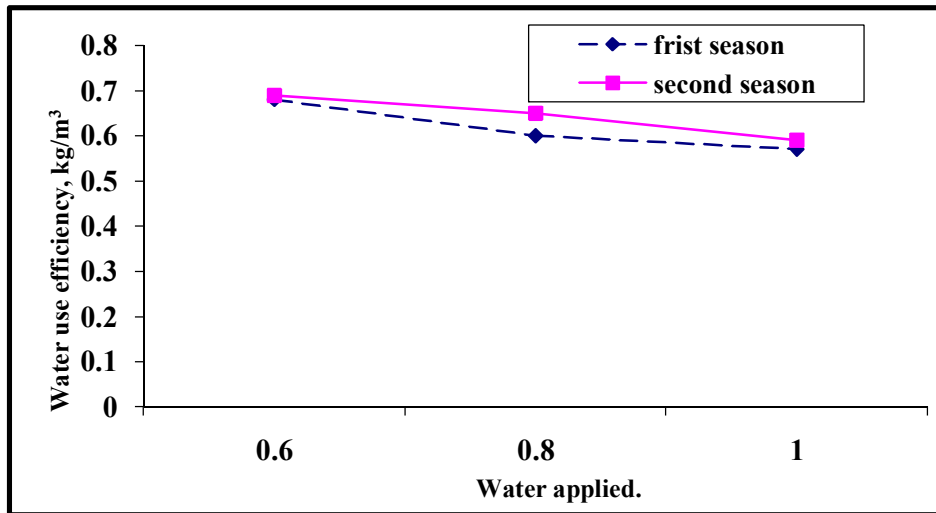
Fig. 7. Effect of water deficit on water use efficiency .

Conclusion

The main results in the present work can be summarized and concluded   in the following points:

Effect of some irrigation systems

Saving in irrigation water by using sprinkler irrigation system was 47.85 and 45.50 % in two seasons comparing with surface irrigation. Yield increased by 10.16 and 12.52 % under sprinkler system   irrigation comparing with surface irrigation in the first and second seasons. Water use efficiency under surface irrigation decreased by 52.7 and 53.6%   respectively   comparing with sprinkler irrigation in two seasons

Effect of irrigation levels.

Amount of irrigation water decreased from 1057.8   to 860,36 and 662.58during the first season . It decreased from 1007.3 to 820.24 and 663.17 m /fed. during the second season . Cumin yield decreased by 14.05, 25.6 ,14.29and 26.89 %respectively under 0.8 and 0.6 ETc comparing by 1.0 ETc   in the two seasons .

Water use efficiency increased   by 5.26 , 19.30 , 10.17 and 16.9 % respectively in two seasons comparing with 1.0 ETc applied water .

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إدارة الري بالرش على محصول الكمون فى الوادى القديم

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اجريت هذه التجربة بمحافظة الغربية لدراسة تاثير نظام الرى بالرش تحت معدلات مختلفة من بخرنتح النبات (١ و ٨ , و ٦ , من ETc) مقارنة بالرى السطحى خلال موسمى التجربة ٢٠٠٩/٢٠١٠,٢٠١٠/٢٠١١على محصول الكمون .

وكانت أهم النتائج كالتالى :

اختلفت قيم معامل المحصول باختلاف مراحل النمو حيث زادت من مراحل النمو الاولى الى مراحل الاثمار ثم انخفض وكانت النتائج كالتالى ٣٥, و ٧٥ , و ١ و ٧٥ , و ٥٠, على التوالى.

تتأثر الاحتياجات المائيه للنبات باختلاف مراحل النمو،حيث كان متوسط عمق المياه المضافة خلال الموسمين هى ٢٨مم خلال ٢٠ يوم و٤٨مم خلال ٣٠يوم و٦٨مم خلال ٣٠يوم و ٤٠ مم خلال ٢٠ يوم و٢٠ مم خلال ١٠ أيام .

أدى استخدام الرى بالرش الى توفيرمياه الرى المعطاه بنسب ٤٧, ٥٨ و٤٥, ٥٠ %خلال موسمى الزراعة مقارنة بالرى السطحى، كما زادت الانتاجية تحت الرى بالرش بنسب ١٦, ١٠ و٥٢, ١٢ % زادت كفاءة أستخدام المياه بنسبه ٥٢,٨٥% عند استخدام نظام الرى بالرش مقارنة بالرى السطحى وعليه تناقصت كمية ماء الرى المضافة من ١٠٥٧.٨ الى ٨٦٠.٣٦ و٦٦٢.٥٨ م ³ /فدان خلال الموسم الأول .وكذلك تناقصت من ١٠٠٧.٣ الى ٨٢٠.٢٤ و٦٣٣.١٨ م ³ /فدان خلال الموسم الثانى تحت الرى بالرش من ١ الى ٨ , ٦ , من ETc البخر نتح النبات .كدللك نقصت الانتاجية بنسب ٢٥.٦ و٢٦.٨٩ % عند الرى ٠.٦من ETc بخر نتح النبات خلال موسمى الزراعة و ايضا نقص الإنتاجية بنسبة ١٤.٠٥ و ١٤.٢٩ % عند الرى بمعامل ٠.٨ مقارنة بمعامل ١ من بخرنتح النبات (ETc) خلال موسمى الزراعة .على العكس زيادة كفاءة استخدام مياه الرى من ٥٧ , الى ٦٠, و ٦٨, كجم / م٣ على التوالى خلال الموسم الاول وفى الموسم الثانى كانت ٥٩ , و ٦٥, و٦٩ , كجم / م٣على التوالى تحت الرى بالرش من ١ الى ٨ , و ٦ , من ETc البخر نتح النبات .

نوصى تحت ظروف محافظة الغربية للحصول على اعلى انتاجية و توفيرمياه الرى لمحصول الكمون بأستخدام الرى بالرش تحت مستوى رى 1.0 Etc .