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REGULAR ARTICLE

IRRIGATION SCHEDULING AND WATER REQUIREMENTS FOR COWPEA USING EVAPORATION PAN AT MIDDLE OF IRAQ

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ABSTRACT

The present study was conducted to find out the water requirements and most suitable irrigation frequencies for cowpea (*Vigna unguiculata* L.) var grown under drip irrigation. The treatments were based on the IW: CPE ratio at different empirical pan factors 0.6, 0.8, 1.0, 1.,1.4, and 1.6 Ef (where Ef = IW/CPE). It was observed that the irrigation interval was variable values decreased by increasing Ef value and with the progress of the growing season. The 1.2 and 1.0 IW: CPE treatments with approximately 4 d irrigation interval were achieved the best results. The total amount of applied water during Cowpea growing season was varied between 247.7 and 266.5 mm with 254.8 mm as a mean. Irrigation treatment with Ef1.2 was superior over the rest of other treatments in fresh seed yield (5.13 ton. hec.$^{-1}$), crop water productivity (2.14 kg. m^{-3}), biological yield (6.88 ton. hec.$^{-1}$), fresh pod yield (7.33 ton. hec.$^{-1}$), weight of 100 seed (31.28 gm), number of seed/pod (9.34) and netting percentage (37.1). The lowest values of the most parameters used in this study were obtained by Ef 0.6 irrigation treatment.

Keywords: Irrigation scheduling, Drip irrigation, Cowpea, Pan evaporation

INTRODUCTION

Throughout the world about 70% of total water is used for irrigation. Reports showed there will be significant increase in the irrigation requirements [3]. As noted in another work [2] the practices that increase the productivity of irrigation water use may provide significant adaptation potential under future climate change. Therefore, improvements in irrigation practices is highly demanding, like drip irrigation [6]. However, these benefits can only be realized if drip irrigation systems are designed and managed properly. At present, Iraq is facing two main problems, increasing population and water shortage. So, less water is available for agricultural production. In addition, the war and the regional conflicts led to poor management of water resources resulted to isolated more agricultural lands, that can be maximizing the agricultural uses under natural and peaceful circumstances [12].

Increasing water use efficiency should be one of the major goals increasing the production of vegetable as well as field crops from the water unit. Vegetable crops require more water and more frequent irrigations than the most of field crops. Little activities could be done to reduce water needs for any given vegetable. Cowpea (*Vigna unguiculata* L.) is one of the main legumes grown in Iraq from March until September. It is grown for green pods and dry seeds. It considered as a good source of protein, energy and other nutrients. It can be grown in a wide range of soils.

Scientific irrigation scheduling with a deep understanding of soil-water-atmospheric relationship is very important for successful irrigation water management [18].

Summer cowpea irrigated according to a schedule based on IW/CPE ratio of 0.8 recorded the maximum dry matter production [29]. Fodder cowpea varieties CO-5, COFC-8, UPC-618, UPC-622, Bundel Lobia-1 are high yielding and suitable for cultivation in Kerala [9] It is the most widely cultivated fodder legume in areas where rainfall is scanty and soils are relatively infertile. Most households that keep livestock raise fodder cowpea as an intercrop with other crops and fodder cowpea forms an integral component of crop livestock farming system [21, 25]. A previous study [26] abstained Cowpea water consumptive by 6.8 mmd^{-1} under dry conditions, while other works [24, 13, 1, 27] obtained Cowpea water consumptive use under different climatic conditions were 337, 288, 669 and 306 mm respectively. Many researchers used the concept of irrigation scheduling based on the metrological data for the relationship between irrigation water (IW) and cumulative percentage of evaporation (CPE) [20, 15]. [16] found that the peanuts need higher irrigation frequencies during pegging stage to pod formation, they also found

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that higher pod yield and water use efficiency were happened by using irrigation treatment with Ef 0.5 during planting stage, and Ef 0.9 during pegging–pod formation, and Ef 0.7 during pod development-flowering. The higher yield of peanuts was registries in sandy loam soil texture at irrigation scheduling by 1.0 IW: CPE [17, 22], but [11] found the best results under the same conditions by using 0.75 IW: CPE.

So, the main objectives of the present study are: Obtain the most suitable irrigation interval for cowpea under precise drip irrigation system using class A pan evaporation and achieve the best crop water productivity at middle of Iraq.

MATERIALS AND METHODS

A field experiments was conducted during spring season 2015 at the Agricultural field of-Baghdad University-Iraq. The location lies on longitude 44° 16' 36" east and latitude 33° 18' 23" north, and 34 m above sea level. The texture of soil was silt clay loam (123 sand), (391 clay), and (486 silt), the field capacity and wilting point was 31.3 and 13.5%, respectively, having pH value of 7.8 in soil paste and EC value of 1.87 dS. m^{-1} in soil paste extract. Soil bulk density was 1.32 g. cm-3, The values of cumulative pan (CPE) was obtained from Al-Raed-meteorological Station Abu-Graib.

The experimental field was ploughed twice by using chisel ploughed. A disk harrow was also used to find suitable seed-bed size aggregates and then, the soil was leveled. The field was watered (73.3 mm) at level approach to field capacity, before planting date in 28/3/2015, and then irrigated with water depth equal to 42 mm for seed growing. Irrigation water treatments were started after the complete emergence corresponding to 10/4/2015. and stopped depending upon irrigation treatments at maturity stage, where the maturity stage dates were 26,26,27,28,29 July 2015 for irrigation treatments,0.6, 0.8, 1.0, 1.2, 1.8 Ef, respectively and 1 August 2015 for 1.4 Ef. The corresponding CPE for each pan factor (Ef) could be computed, which is resulting in identifying the number of days at which irrigation event should be executed. The amount of applied irrigation water during the irrigation treatments was according to crop evapotranspiration (ET_c), The total depth of water applied was computed according the treatments. Plant characteristic, yield for Cowpea and water productivity also computed.

Nitrogen, phosphorus, and potassium fertilizers were applied as recommended through fertigation technique. The treatments were arranged in randomized complete plot design with three replicates. The plots (84 m2) were randomly assigned to six irrigation scheduling which are;

1. Irrigation at 60% of class A pan evaporation (Ef 0.6).
2. Irrigation at 80% of class A pan evaporation (Ef 0.8).
3. Irrigation at 100% of class A pan evaporation (Ef 1.0).
4. Irrigation at 120% of class A pan evaporation (Ef 1.2).
5. Irrigation at 140% of class A pan evaporation (Ef 1.4).
6. Irrigation at 160% of class A pan evaporation (Ef 1.6).

In this study theoretical AW for 45 cm depth is 106 mm. multiply this result by 30% (AMD for cowpea) to get the actual AW should be used in all treatments calculate will be 32 mm. Therefore, the available water to be extracted by pea plants will be 32 mm.

The irrigation interval per each treatment is the number of days in which the cumulative pan evaporation (CPE) should be approximately equals the estimated water amount of the considered treatment as follows:

$$E_f = IW/CPE$$

Where: CPE= cumulative pan evaporation, Ef= Empirical pan factor (0.6, 0.8,1.0, 1.2, 1.4and1.6), IW= irrigation water applied which equal to $AW \times AMD$.

AW= Available water (mm) for the soil for effective root zone depth, and AMD= Allowable moisture depletion by setting lower limit 30%. Then, it could identify the number of days should be irrigated depends upon the CPE values.

Crop water productivity (CWP), Kg/m^3 which defined as water utilization efficiency was calculated according to [4] which equal yield divided by irrigation water applied. Yield and its components were recorded such as; Biological yield. Fresh pod yield. Fresh seed yield. Weight of fresh 100 seeds. Number of seeds/pod yield, Netting percentage (%),(weight of green seed per weight of green pod) and Pod filling, ((Number of seeds/pod/Pod lenhgt(cm) . The collected data were subjected to the statistical analysis, using the analysis of variance (ANOVA). The Duncan's multiple range test was used to compare between the means [28].

RESULTS AND DISCUSSION

Table 1 indicated that irrigation interval decreased by increasing in IW: CPE ratio and with progress of growing season. The irrigation interval value for treatment of 0.6 Ef was 10,8,6 and 10 d in April, May, June and July respectively. On the other hand, irrigation interval was 4, 3, 2 and 2 for 1.6 Ef treatments. Also values of irrigation intervals decreased by 10, 8, 6, 5,4 and 4 in April as compared with 6,4,3,3, and 2 in July for the irrigation treatments 0.6, 0.8,1.0,1.2,1.4 and 1.6 Ef respectively. The higher value of irrigation interval was 10 d for 0.6 Ef treatments in April, while the lowest value was 2 d for 1.6Ef treatment in July.

Adoption of irrigation scheduling based on IW: CPE ratio with the precis irrigation interval as with 1.0 and 1.2 Ef treatments achieved the drip irrigation concept. The total irrigation intervals at a period of 120 d (growing season) were approached to 28-33, which was mean 3-4 d. It considers a suitable interval as compared to irrigation frequencies which decreased for treatments with less than 1.0 Ef and increased for treatments more than 1.2 Ef.

The amount of water applied was varied between all treatments. It could be resulted from different maturity stage dates which differ between treatments according to water stress which occur due to elongate the irrigation interval thought the studied treatments. High significant effects also resulted between treatments on fresh seed yield. The highest mean fresh seed yield in the season of the study (5.13 ton. hec^{-1}.) was obtained when we irrigate at Ef 1.2 and the lowest fresh seed yield (4.81 ton. hec^{-1}.) was obtained when Ef 0.6 was used. Thus, it can be lead that the yield not only function of amount of applied water but it is a function also of time of watering. Regarding crop water productivity, data in table (2) reveal that the highest value of CWP (2.140 kg m^{-3}) was resulted from using Ef 1.2 and the lowest CWP (1.943 kg m^{-3}) was obtained by using Ef 0.6. These results agreed with [14 and 5].

Table 1: Irrigation intervals (day) and depth of irrigation water (mm) under different empirical pan factors

Month of year	IW: CPE (Ef)	CPE	ETpan (mm. d-1)	Irrigation intervals (day)	No. of irrigations	irrigation water per months(mm)	Depth of irrigation water per month(mm)
April	0.6 IW: CPE	53.00	5.22	10	2	42.4	84.80
	0.8 IW: CPE	39.75		8	3	32.0	96.00
	1.0 IW: CPE	31.80		6	3	25.6	76.80
	1.2 IW: CPE	26.50		5	4	21.6	86.40
	1.4 IW: CPE	22.71		4	5	18.4	92.00
	1.6 IW: CPE	19.87		4	5	16	80.00
May	0.6 IW: CPE	53.00	6.97	8	4	5.08	20.32
	0.8 IW: CPE	39.75		6	5	3.84	19.0
	1.0 IW: CPE	31.80		5	6	3.07	18.42
	1.2 IW: CPE	26.50		4	8	2.59	20.72
	1.4 IW: CPE	22.71		3	10	2.20	22.00
	1.6 IW: CPE	19.87		3	10	1.92	19.20
June	0.6 IW: CPE	53.00	8.54	6	5	10.17	50.85
	0.8 IW: CPE	39.75		5	6	7.68	46.08
	1.0 IW: CPE	31.80		4	8	6.14	49.12
	1.2 IW: CPE	26.50		3	10	5.18	51.80
	1.4 IW: CPE	22.71		3	10	4.41	44.10
	1.6 IW: CPE	19.87		2	15	3.84	57.60
July	0.6 IW: CPE	53.00	8.81	6	5	10.17	50.85
	0.8 IW: CPE	39.75		4	7	7.68	53.76
	1.0 IW: CPE	31.80		3	10	6.14	61.40
	1.2 IW: CPE	26.50		3	10	5.18	51.80
	1.4 IW: CPE	22.71		2	15	4.14	6.10
	1.6 IW: CPE	19.87		2	15	3.84	57.60

Table 2: Seasonal water applied, fresh seed yield and crop water productivity, for different treatments

Treatments (Ef)	IW, (m^3. hec^{-1})	Fresh seed yield (ton. hec^{-1})	CWP (Kg. m^{-3})
0.6	248.82	4.81d	1.943f
0.8	257.04	501c	1.967e
1.0	247.74	5.08b	2.096b
1.2	252.72	5.13a	2.140a
1.4	266.25	5.02f	1.964d
1.6	256.40	5.08e	2.010c

Data in table 3 presents the biological yield, fresh pod yield and its components as affected by different treatments. The highest value of biological yield (6.88 ton. hec^{-1}) was obtained with the treatment of Ef 1.2, where the lowest value (6.5ton. hec^{-1}.) was obtained with the treatment irrigated at Ef 0.6. on the other hand the highest fresh pod yield (7.33 ton. hec^{-1}.) and the lowest value (4.78 ton. hec^{-1}.) was obtained from treatment irrigated at Ef 1.2, and Ef0.6, respectively. Similar results were found by [23]. Significant differences were found regarding to weight of 100 seeds and non-significant differences found regarding of percentage of moisture in seeds. So, it can be stated that the studied treatments have a significant effects on weight of 100 seeds. Because the moisture in seed considers the main component of about 70.9-72.5% of seed weight. Tabulated data in table 3 also show that significant effects on netting percentage were resulted from the studied treatments, the highest value (37.1%) was obtained from irrigation at 1.2 treatments, while the lowest (24.1%) was resulted from irrigation at 0.6 treatment. Regarding pod filling, there are highly significant differences between studied treatments. The highest mean value (0.616 and 0.627) was resulted from irrigation at Ef (1.2, and 1.0) treatments. On the other hand, the lowest value (0.511%) of the pod filling was obtained from irrigation at Ef 1.4.

The data showed that there were a significant differences between treatments in biological yield (fig 1), however Ef 1.2 treatment was superior over the rest of the others in this parameter, followed by 1.0 IW: CPE by 6.75 ton. hec^{-1}. compared with the lowest biological yield by 6.5 ton. hec^{-1} which was obtained with the treatment of Ef 0.6. A significant 2^{nd} degree equation relationship $(y = -0.0411 \times^2 + 0.3009 \times +6.48)$ with $R^2 = 0.7773$ was obtained as result of irrigation intervals treatments and biological yield relationship.

Table 3: Biological yield and green pods yield and its components as affected by different treatments

Treatments (Ef)	Biological yield (ton. hec⁻¹.)	Fresh pod yield ton. hec⁻¹	Wet of 100 seed(gm)	Number of seeds/pod	Netting percentage (%)	Pod filling	Percentage of moisture in seeds, %.
0.6	6.5f	4.75b	27.81de	7.23f	24.1c	0.575d	70.30b
0.8	6.7c	4.97b	7.51ef	8.60c	30.7b	0.595c	72.0ab
1.0	6.75b	4.83b	30.58b	9.115b	25.6c	0.627a	73.19a
1.2	6.88a	7.33a	31.28a	9.34a	37.1a	0.616b	71.1 ab
1.4	6.63d	6.38b	29.48bc	8.17d	35.3a	0.511f	71.4 ab
1.6	6.61e	7.06a	28.58cd	7.53e	31.9b	0.532e	72.0 ab

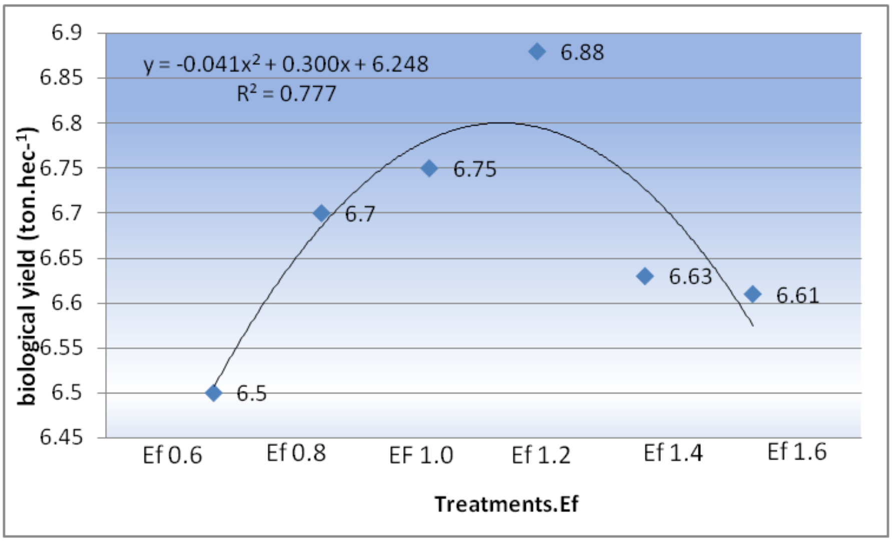

Fig. 1: The relationship between irrigation treatments and biological yield of Cowpea crop

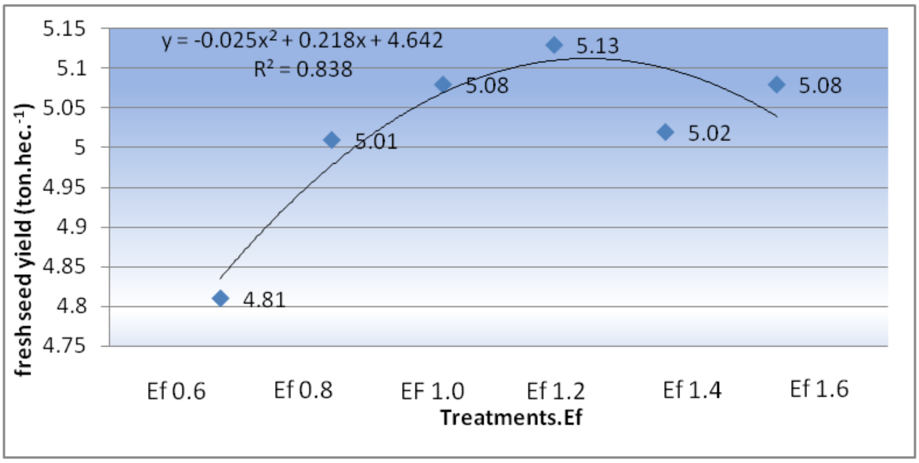

Fig. 2: The relationship between irrigation treatments and fresh seed yield of Cowpea crop

A significant positive correlation relationship between irrigation treatments and fresh seed yield according to the quadratic equation $(y = -0.0254 + 0.2184x + 4.642)$ with $R^2 = 0.0.8383$.

CONCLUSION

Finally, it could also be concluded that, yield is not only function of amount of applied water but it is a function of time of watering. Irrigation scheduling which based on daily evaporation records is more efficient for effective irrigation from point of water view. The effective evaporation empirical factor of cowpea is 1.2 if could be implemented at the short water rotation and use 1.4 at long water rotation which produce high yield and high crop water productivity.

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