$$Cu = 100\left|1 - \frac{\sum(xi - x`)}{nx`}\right| \quad (4)$$

Where: Cu = the coefficient of uniformity expressed in %; xi = the individual collected water application depth from catch cans in mm; $x`$ = the average of all xi in mm; and n =the total number of catch cans used in the evaluation.

2.7 Application Efficiency of Low Quarter

The application efficiency of low quarter (AELQ) was calculated by **[13]** formula as follows:

$$\text{AELQ} = \left[\frac{Z_{r,lq}}{D}\right] \times 100 \quad (5)$$

Where: AELQ = the application efficiency of low quarter in %, $Z_{r,lq}$ = the average low quarter depth of collected water in mm, and D = the average depth of water applied in mm.

2.8 Water Use Efficiency

The water use efficiency was determined according to **[14]**as follows:

$$\text{WUE} = \frac{\text{Y}}{\text{Q}} \quad (6)$$

Where: WUE = water use efficiency in $kg.m^{-3}$, Y = grain yield in $kg.ha^{-1}$, and Q = applied water in $m^3.ha^{-1}$.

2.9 Energy Use Efficiency

The energy use efficiency was determined using the following equation:

$$\text{EUE} = \frac{\text{Y}}{\text{E}_r} \quad (7)$$

Where: EUE = energy use efficiency in $kg.kW^{-1}.h^{-1}$, Y = grain yield in $kg.ha^{-1}$, and E_r = energy consumption in $kW.h.ha^{-1}$.

3. Results and Discussions

3.1 The Amount of Applied Water

The amounts of applied water for flood irrigation and sprinklers (100% ETc and 50% ETc) are shown in Figure 1. The amounts of applied water were 5077, 4201, and 3068 $m^3.ha^{-1}$ for flood irrigation, and sprinklers (100% ETc and 50% ETc), respectively. These results showed that the maximum applied water of 5077 $m^3.ha^{-1}$was recorded with flood irrigation, while the minimum applied water of 3068 $m^3.ha^{-1}$ was recorded with 50% ETc of sprinkling method. However, it is interesting to mention that the water savings were 17% and 40% for 100% and 50% ETc, respectively in comparison with the control treatment.

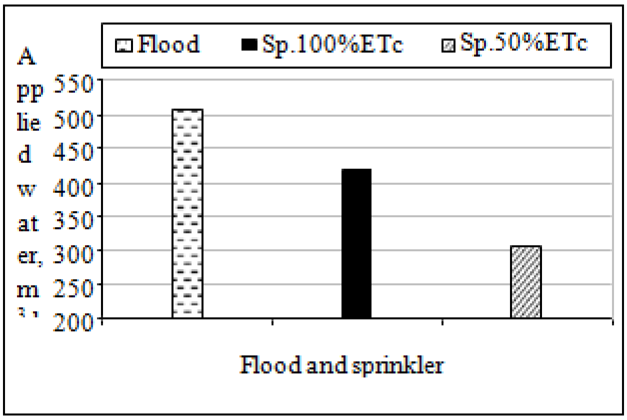

Figure 1: The amount of applied water under different irrigation regimes

3.2 Effect of Sprinklers Layouts on Distribution Uniformity, Coefficient of Uniformity and Application Efficiency of Low Quarter

The results in Table 2 indicate the values of distribution uniformity for square and triangular layouts. It values were 77.24% and 73.47% for square and triangular layouts, respectively. The values of coefficient of uniformity were 78.28% and 78.22% for square and triangular layouts, respectively. The values of application efficiency of low quarter were 73.15% and 70.53% for square and triangular layouts, respectively. The results explained that the highest values of distribution uniformity, coefficient of uniformity, and application efficiency of low quarter were achieved by square layout. However, the lowest one was achieved by triangular layout.

Table 2: Effect of sprinklers layouts on distribution uniformity, coefficient of uniformity, and application efficiency of low quarter

Sprinklers layouts	Distribution uniformity, (%)	Coefficient of uniformity, (%)	Application efficiency of low quarter, (%)
Square	77.24	78.28	73.15
Triangular	73.47	78.22	70.53

3.3 Effect of Watering and Fertilizer Levels on Biomass, Grain Yield and Straw Yield Under both Square and Triangular Layouts

The results in Table 3 indicates the effect of watering and fertilizer levels on biomass, grain yield, and straw yield using square layout and triangular layout. The highest value of biomass (15.35 $Mg.ha^{-1}$) was obtained by treatment S_1. It was a minimum value (12.14 $Mg.ha^{-1}$) by treatment S_4. However, the lowest value (9.91 $Mg.ha^{-1}$) was obtained under flood irrigation. The maximum value of grain yield (5.70 $Mg.ha^{-1}$) was obtained by treatment S_1. It was a minimum value (4.82 $Mg.ha^{-1}$) by treatment S_4. However, the lowest value (4.55 $Mg.ha^{-1}$) was obtained under flood irrigation. The highest value of straw yield (9.65 $Mg.ha^{-1}$) was obtained by treatment S_1. It was a minimum value (7.33 $Mg.ha^{-1}$) by treatment S_4. However, the lowest value (5.36 $Mg.ha^{-1}$) was obtained by flood irrigation. These results agree with the study of **[3]**. The results in Table 3 presented also that, the highest value of biomass (13.08 $Mg.ha^{-1}$) was

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obtained by treatment T_1 using triangular layout. It was a minimum value (10.82 $Mg.ha^{-1}$) by treatment T_4. However, the lowest value (9.91 $Mg.ha^{-1}$) was obtained by flood irrigation. The maximum value of grain yield (5.03 $Mg.ha^{-1}$) was obtained by both treatments T_1 and T_3. It was a minimum value (4.79 $Mg.ha^{-1}$) by treatment T_4. However, the lowest value (4.55 $Mg.ha^{-1}$) was obtained by flood irrigation. The highest value of straw yield (8.05 $Mg.ha^{-1}$) was obtained by treatment T_1. It was a minimum value (6.04 $Mg.ha^{-1}$) by T_4. However, the lowest value (5.36 $Mg.ha^{-1}$) was obtained by flood irrigation.

Table 3: Effect of watering and fertilizer levels on biomass, grain yield, and straw yield under both square and triangular layouts

Treatments	Biomass, ($Mg.ha^{-1}$)	Grain, ($Mg.ha^{-1}$)	Straw, ($Mg.ha^{-1}$)
S_1	15.35	5.70	9.65
S_2	13.12	5.00	7.80
S_3	12.98	4.90	7.95
S_4	12.14	4.82	7.33
C	9.91	4.55	5.36
T_1	13.08	5.03	8.05
T_2	12.90	4.95	7.96
T_3	12.60	5.03	7.80
T_4	10.82	4.79	6.04
C	9.91	4.55	5.36

3.4 Effect of Watering and Fertilizer Levels on Water Use Efficiency Using both Square and Triangular Layouts

Figure 2 illustrate that, the highest value of water use efficiency "WUE" (1.58 $kg.m^{-3}$) was obtained by treatment S_3 in the case of square layout. It was 1.18 $kg.m^{-3}$ by treatment S_2. In the case of triangular layout, the highest value of WUE (1.64 $kg.m^{-3}$) was obtained by treatment T_3. It was 1.16 $kg.m^{-3}$ by treatment T_2. However, the lowest value of WUE (0.90 $kg.m^{-3}$) was obtained by flood irrigation.

3.5 Energy Consumption

The results in Figure 3 indicated that, the values of energy consumption were 412, 333, and 276 $kW.h.ha^{-1}$ for sprinkler at 100% ETc, flood irrigation, and sprinkler at 50% ETc, respectively. These results showed that the maximum value of the energy consumption was 412 $kW.h.ha^{-1}$ by using sprinklers at 100% ETc. However, the lowest value of the energy consumption was 276 $kW.h.ha^{-1}$ using sprinkler at 50% ETc.

3.6 Effect of Watering and Fertilizer Levels on Energy Use Efficiency Using both Square and Triangular Layouts

Figure 4 illustrates the values of energy use efficiency "EUE" using different irrigation regimes. In the case of square layout, the highest value of EUE (17.52 $kg.kW^{-1}.h^{-1}$) was obtained by treatment S_3. However, the lowest value (12.04 $kg.kW^{-1}.h^{-1}$) was obtained by treatment S_2. In case of triangular layout, the highest value of EUE (18.20 $kg.kW^{-1}.h^{-1}$) was obtained by treatment T_3. However, the lowest value (11.88 $kg.kW^{-1}.h^{-1}$) was obtained by treatment T_2. On the other hand, the value of EUE was 13.66 $kg.kW^{-1}.h^{-1}$ using flood irrigation. From the results, the treatments of the square layout produced good results compared to the triangular layout. Treatments of 100% ETc produced best results compared to 50% ETc. Also, treatments of 100% fertilizer recommended dose produced best results compared to 75% fertilizer recommended dose.

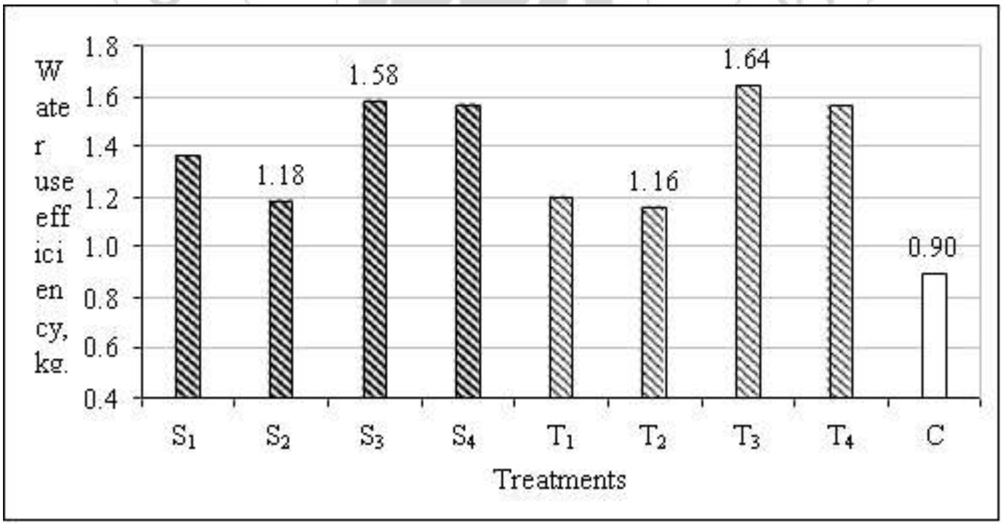

Figure 2: Effect of watering and fertilizer levels on water use efficiency using square and triangular layouts

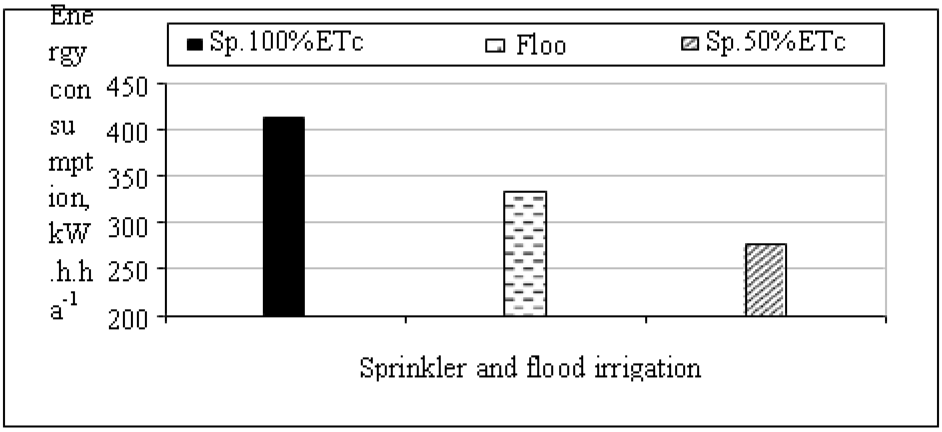

Figure 3: The energy consumption using different irrigation regimes

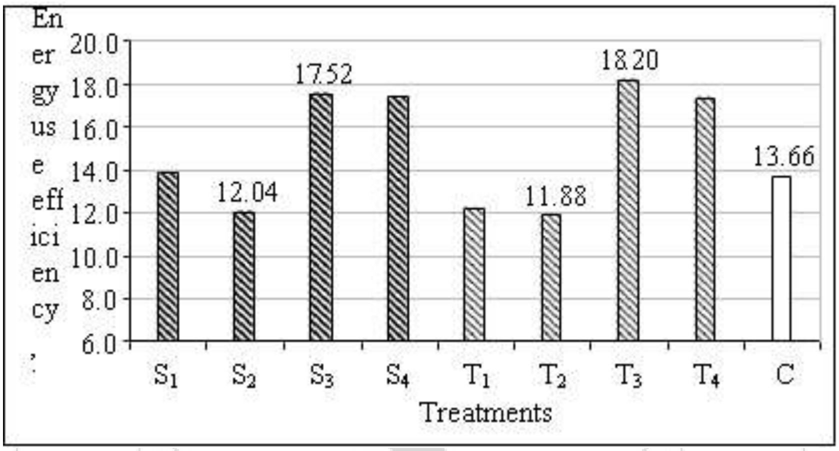

Figure 4: The energy use efficiency using different irrigation regimes

4. Conclusions

From the above mentioned investigation, conclusions can be drawn from the following:

Sprinkler irrigation with 100% ETc and 50% ETc saved water by 17% and 40%, respectively compared with flood irrigation. The highest values of water distribution uniformity, coefficient of uniformity, and application efficiency of low quarter were achieved by square layout. The highest value of WUE (1.64 kg.m^{-3}) was obtained by treatment T_3. It was 1.16 kg.m^{-3} by treatment T_2. However, the lowest value of WUE (0.90 kg.m^{-3}) was obtained using flood irrigation. In conclusion, sprinklers square layout at 100% ETc with 100% fertilizer gave the best results.

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