SUMMARY

Two field experiments were carried out at the farm of Agric. Res. Center, Giza, Egypt, during 1993/1994 and 1994/1995 seasons to manage flax irrigation (scheduling irrigation according to the Class A pan evaporation records) under three sowing dates. The effect of sowing dates and irrigation regimes on flax yield and its components, oil content, some technological character of fibers, and the crop water use were studied. Also, the potential evapotranspiration and Class A pan relation to climate and crop water use were estimated.

Flax cultivar, Giza 8 a double purpose variety was used in both seasons. The experimental design was split-plot with four replications. Sowing date treatment were arranged at random in the main plots and the irrigation regimes (scheduling irrigation) treatments were assigned randomly with the sub-plots. The sub-plot area was 10.5 m^2 (3.0 x 3.5 m) and each sub-plot was isolated by leaves 1.2 from other plots to avoid the water lateral movements during irrigation. The experimental treatments were as follows:

A. Sowing dates

1. Early sowing (October 20th)
2. Medium sowing (November 10th)
3. Late sowing (December 1st)

The period between intervals were 3-weeks.

B. Irrigation regimes

I_1: Irrigation at 0.8 accumulative pan evaporation (APE)

I_2: Irrigation at 1.0 accumulative pan evaporation

I_3: Irrigation at 1.2 accumulative pan evaporation

I_4: Irrigation at 1.4 accumulative pan evaporation

The Class A pan used in the recommended type by the World Meteorological Organization. It located very close to field and all factors affecting its records were considered. The available soil moisture in the soil profile from soil surface till 45.0 cm depth has been converted to units of water depth in mm and was found to be 82.0 mm. The crop plants were irrigated when the water balance in the root zone reached zero, i.e. irrigation when the accumulative pan evaporation records multiplied by the rates 0.8, 1.0, 1.2 or 1.4 are equal to the available soil moisture content or to 82.0 mm.

The soil was clay loamy with pH of 7.4 Flax seeds were broadcasted at the rate of 60.0 kg/fed. Calcium super phosphate (15.5 P_2O_5) was applied at the rate of 100 kgs/fed before planting. Nitrogen fertilizer was added in the form of urea (46.0% N) at the rate of 70 kg N/fed. in two doses. The normal cultural practices for growing flax were used during the two seasons. Irrigation regime treatments were applied after the first irrigation till the end of the growing season.

Characters studied:

I. Yield and yield components

1. Total plant height (cm).
2. Technical length (cm).
3. Number of fruiting branches/plant.
4. Stem diameter (mm).
5. Capsules number/plant.
6. Seeds number/plant.
7. Seed yield/plant (gm).
8. 1000-seed weight (gm)

9. Straw yield/plant (gm).
10. Seed yield (Kg/fed).
11. Straw yield (Kg/fed).
12. Fiber yield (Kg/fed).

II. Oil content

1. Oil percentage in seeds (%)
2. Oil yield (kgs/fed)

III. Technological properties of fibers

1. Fiber percentage, (%)
2. Fiber length (cm),
3. Fiber strength (R.K.m.),
4. Fiber fineness (N.m.)

IV. Crop water use:

1. Actual evapotranspiration (ETc)
   i. Seasonal ET (cm)
   ii. Daily ET rates (mm/day)
2. The Class A pan evaporation studies:
   i. Pan evaporation and some climatic factors relations.
   ii. Pan evaporation and actual daily Et rates relation
3. Potential evapotranspiration (ETp)
   i. Monthly ETp
   ii. Seasonal ETp
4. Crop coefficient (Kc)
5. Water use efficiency (WUE)
   i. WUE in kg seeds/m^3 water

ii. WUE in kg fibers/m^3 water.

The main results can be summarized as follows:

I. Yield and yield components:

A. Effect of sowing dates:

1. Sowing flax early on October 20th significantly increased total plant height, technical length, number of fruiting branches/plant, stem diameter, 1000-seed weight, straw yield/plant and per feddan in both seasons.
2. Capsule number/plant, seed number/plant, seed yield/plant and per feddan, as well as fiber yield/feddan were increased significantly when flax plants were sown on November 10th in 1993/94 and 1994/95 seasons.
3. The late sowing of December 1st produced the lower means of yield and yield components in the two seasons under study.

b. Effect of irrigation regimes:

1. Total plant height, technical length, stem diameter, straw yield/plant and per feddan were significantly higher when irrigation was practiced at 1.4 accumulative pan evaporation (short irrigation intervals), in the two seasons.
2. Irrigating flax plants at 1.2 accumulative pan evaporation (APE) significantly increased number of fruiting branches/plant, capsules number/plant, seeds number/plant, seed yield/plant, 1000-seed weight, seed and fiber yield/feddan than irrigation at 1.4, 1.0 or 0.8 APE in 1993/94 and 1994/95 seasons.

3. Prolonged irrigation intervals (irrigation at 0.8 APE) produced significant decreases in flax yield and its components in both seasons.

C. Effect of the interaction:

1. Total plant height, technical length, stem diameter, straw yield per plant and per feddan were significantly increased to higher values when flax was sown on October 20th (early) and plants irrigated at 1.4 APE (short intervals) in both seasons.
2. Sowing flax on October 20th and irrigation at 1.2 APE (moderate intervals) produced the higher means of number of fruiting branches/plant and 1000-seed weight in the two seasons under study.
3. The second sowing date (November 10th) and practicing irrigation at 1.2 APE (moderate intervals) significantly increased capsules and seeds number/plant, seed yield/plant, seed yield/fed and fiber yield/fed to their higher values in 1993/94 and 1994/95 seasons.
4. The lower means of yield and yield components were observed from delaying sowing date of flax to the first of December and subjecting plants to water stress or irrigation at 0.8 APE (prolonged irrigation intervals) in both seasons.

II. Oil content

A. Effect of sowing dates:

1. The higher oil percentages in flax seeds were 42.04 and 41.59%, obtained from the second sowing date (Novemebr 10th) in 1993/94 and 1994/95 seasons, respectively.

2. Sowing flax 3-week early or later than November 10th significantly decreased oil percentage in seeds.
3. The early and the late sowing of flax (October 20th or December 1st) reduced oil yield/fed significantly in both seasons.
4. Sowing flax on 10th November produced the higher means of oil yield i.e. 352.1 and 326.5 kgs/fed in 1993/94 and 1994/95 seasons, respectively.

B. Effect of irrigation regimes:

1. Irrigating flax at short intervals (irrigation at 1.4 APE) gave the higher means of oil percentage in seeds i.e. 40.14 and 39.67% in the two successive seasons, respectively.
2. Oil percentage in seeds significantly decreased as soil moisture decreased from irrigation at 1.4 APE to 1.2, 1.0 and 0.8 APE in both seasons.
3. Oil yield/fed significantly increased when irrigation was applied at 1.2 APE in the two seasons under study.

C. Effect of the interaction:

1. The higher means of oil percentage in flax seed were 42.49 and 42.05%, gained from sowing flax on November 10th and irrigation at 1.4 APE.
2. Sowing flax on November 10th and irrigation at 1.2 APE produced the higher oil yield/feddan in the two seasons (386.3 and 359.5 kgs/fed).

III. Technological properties of fibers:

A.Effect of sowing dates

1. Sowing flax on November 10th increased significantly fiber percentage and fiber fineness in 1993/1994 and 1994/1995 seasons.
2. The early sowing date (October 20th) produced the long fibers when compared with the other two sowing dates in both seasons.
3. Delaying sowing date of flax from October 20th to December 1st significantly increased fiber strength to its higher values in the two seasons under study.

B. Effect of irrigation regimes:

1. Irrigation flax at 1.2 APE gave the fiber percentage i.e. 14.34 and 13.46% in 1993/1994 and 1994/1995, respectively.
2. Irrigation flax plants at short irrigation intervals i.e. irrigation at 1.4 APE significantly increased fiber length and fiber strength to its higher values in both seasons.
3. The higher values of fiber fineness were obtained from irrigation at long intervals (irrigation at 0.8 APE) in the two seasons under study.

C. Effect of the interaction

1. Sowing flax on October 20th (early) and irrigation at 1.4 APE increased fiber percentage significantly in both seasons.
2. The higher fiber length was obtained from sowing flax on November 10th and irrigation at 1.2 APE in 1993/1994 and 1994/1995 seasons.

3. The later sowing of December 1st and short irrigation intervals (1.4 APE) produced the higher values of fiber strength.
4. Sowing flax on November 10th and irrigation at 0.8 APE significantly increased fiber fineness to its maximum values in both seasons.

IV. Crop water use

1. Actual evapotranspiration (ET)

A). Effect of sowing dates

i) Seasonal ET (cm)

- Seasonal ET values by flax irrespective to sowing dates and irrigation regimes were 35.65 and 33.91 cm in 1993/1994 and 1994/1995 seasons, respectively.
- The early sowing of October 20th produced the highest ET values i.e. 38.4 and 36.14 cm in 1993/1994 and 1994/1995 seasons, respectively.
- Delaying sowing date than October 20th decreased seasonal ET by flax to reach its lower values with December 1st sowing (33.29 and 31.92 cm) in both seasons, respectively.

ii) Daily ET rates (mm/day)

- The daily ET rates were low during two initial period (October and November) and increased to reach its maximum at mid-seasons stage through February and March when plants aged 105 - 132, 84 - 112 and 88 - 119 day from sowing for the 1st, 2nd and 3rd sowing

dates, respectively, then redecreased again at late season stage (maturity).

- The maximum daily ET rates at the peak period of water consumption were 3.05 mm/day, obtained from the early sowing date in 1993/1994 seasons. Whereas, in 1994/1995 seasons the later sowing date gave the higher ET rate (3.00 mm/day) on March.

B) Effect of irrigation regimes

i) Seasonal ET (cm)

- Seasonal ET values were 30.55, 33.50, 37.26 and 41.28 cm due to irrigation flax at 0.8, 1.0, 1.2 and 1.4 APE in 1993/1994 season, respectively. In 1994/1995 season the respective values of ET were 29.40, 31.47, 35.43 and 39.33 cm for the same irrigation treatments.
- Seasonal ET values by flax plants increased when the available soil moisture in the root zone increased (frequent irrigation intervals).

ii) Daily ET rates (mm/day)

- Daily ET rates increased as the available soil moisture increased in the root zone (increasing irrigation frequency) in both seasons.
- The maximum values of daily ET rates in 1993/1994 season were 3.82, 3.74 and 3.83 mm/day, obtained from irrigating flax at 1.4 APE (short intervals) for the 1st, 2nd and 3rd sowing dates, respectively, which occurred on February and March (mid-season). The same trend was found in 1994/1995 season and the values were 3.34, 3.18 and 3.29 mm/day for the respective sowing dates.

2. The Class A pan evaporation studies

i) Pan evaporation and some climatic factors relation

- The correlation between the daily Class A pan evaporation and mean daily temperature, mean daily relative humidity and mean daily vapour pressure deficit was highly significant in the two seasons under study.
- The correlation between daily evaporation records and mean daily wind speed was not significant in the two seasons.
- The correlation coefficient values between the Class A pan evaporation and daily mean of air temperature, daily mean of relative humidity and daily mean of vapour pressure deficit were 0.523, 0.5426 and 0.4817, respectively.
- The regression line of the relation between the Class A pan evaporation rates (Y) and mean daily air temperature (X) can be represented by the following formula:

$$Y = 1.2721 + 0.1399X$$

- The linear regression for the relationship between the Class A pan evaporation rate in mm/day (Y) and mean daily relative humidity (X) is as follows:

$$Y = 7.3719 + (-0.0569X)$$

- The linear function of the Class A pan evaporation rate (Y) in mm/day and mean daily vapour pressure deficit (X) in ml.bar relationship can be estimated as follows:

$$Y = 2.8148 + 0.1051X$$

These results reveal that the Class A pan evaporation was closely related to many climatic factor which affecting the evapotranspiration of plants. Therefore, the Class A pan evaporation method is more accurate in estimating short term fluctuations of the ETp and ET crop.

ii) Pan evaporation and actual ET relation

- The relationship between the daily Class A pan records and daily ETc of the early sowing date was not significant at any level of irrigation in both seasons.
- The Class A pan evaporation records were significantly correlated with flax ET/day when plants were irrigated at 0.8 and 1.0 APE, for the November 10^{th} sowing in both seasons. However, pan daily records were significant correlated with flax daily ET of the later sowing at the levels of 0.8, 1.0, 1.2 and 1.4 APE in the two seasons.

It could be concluded that the Class A pan evaporation records can be used a direct method for scheduling flax irrigation sown on November 10^{th} and after that if it well located and all factors affecting evaporation were considered.

3. Potential ET

i) Monthly ETp

- The monthly ETp values were somewhat high during the initial period (October and November). Then monthly ETp values decreased during December and increased again to reach its maximum values during (grain filling) March, then redecreased at late season stage.

- Monthly values of ETp on March were 92.04 and 101.18 mm in 1993/1994 and 1994/1995 seasons, respectively.

ii) Seasonal ETp

- Seasonal ETp values estimated by the Class A pan method in 1993/1994 season were 43.57, 40.97 and 40.25 cm for the early, moderate and late sowing dates, respectively. Whereas, in 1994/1995 season, the ETp values were 41.81, 39.16 and 38.06 cm for October 20th, November 10th and December 1st sowing dates, respectively. These differences may be due to the differences in growing season length of each sowing date.

4. Crop coefficient (Kc)

- The crop coefficient values started with low rates during October and November (initial period) and increased gradually after that to reached its maximum value on February (mid-season), then redecreased again till the end of season (April and May).
- The Kc value ranged from (0.5-0.722) on October and November, whereas its value at mid-season was 1.11. At late-season, it ranged from 0.541 -0.557.
- The higher Kc values at any growth stage (any month) of the growing season were obtained from the early sowing date. However, the lower monthly Kc values were resulted from the late sowing date in both seasons.
- Seasonal Kc were 0.856 and 0.854 in 1993/1994 and 1994/1995, respectively.

- Irrigation flax at 1.4 APE produced the higher monthly Kc values at any growth stage in both seasons, as well as the seasonal Kc. The lower ones were obtained from irrigation at 0.8 APE.

5. Water use efficiency (WUE)

i) WUE for seeds (kgs seeds/m³ water)

- Sowing flax on November 10th is more efficient in water utilization than the early or the late sowing dates.
- Each cubic meter of water applied to the medium sowing date plants produced 0.575 and 0.558 kgs seeds in 1993/1994 and 1994/1995, respectively.
- Irrigation flax plants at 1.2 APE gave the higher values of WUE i.e. 0.503 and 0.494 kgs seeds/m³ water consumed in the two successive seasons, respectively.
- Sowing flax on November 10th and practiced irrigation at 1.2 APE can be recommended for the better utilization of water by flax plants.

ii) WUE for fibers (kgs fibers/m³ water)

- The higher values of WUE were 0.255 and 0.239 kgs fibers/m³ water consumed were resulted from sowing flax on November 10th in both seasons.
- Irrigation flax at 1.2 APE increased WUE to its higher values i.e. 0.228 and 0.217 kgs fibers/m³ water in the two successive seasons, respectively.

- The medium sowing date (November 10^{th}) and irrigation at moderate intervals (1.2 APE) gave the higher values of WUE of fibers/m^3 water (0.266 and 0.256) in 1993/1994 and 1994/1995 seasons, respectively.
- It could be concluded that the second sowing date (November 10^{th}) and irrigating flax plants at 1.2 APE is more efficient practice in utilizing water for seeds and fiber production.