RESULTS AND DISCUSSION

I. Growth Measurements

The effect of sowing dates and irrigation regimes on some soybean growth measurements namely leaf number / plant , leaf area / plant , dry weight /plant at 60 and 90 days old from sowing , as well as the dry weight / plant and plant height at harvesting time are presented in Table (8).

The combined analysis of variance(three seasons)show that sowing dates and irrigation regimes had significant effects on soybean growth measurements at the two growth stages and at harvesting time(Table,8).

1- Leaf number / plant

The data presented in Table(8),show the effect of sowing dates and irrigation regime treatments on the leaf number/plant of soybean at 60 and 90 days old from sowing.

A)- Effect of sowing dates:-

Data in Table(8),prove that the leaf number / plant of soybean was significantly affected by sowing dates at 60 and 90 days old from sowing.

The leaf number/plant significantly decreased at 60 days old by 5.9 and 10.1 % when soybean was planted in mid-April and late May, respectively,as compared with the early May sowing date.

At 90 days old from sowing the same trend was found and the reduction percentages were 5.4 and 12.2%,respectively.

The higher values of leaf number/ plant at 60 days 90 days old were 18.8 and 19.6, resulted from early May sowing date. Whereas,the lower values were(16.9 and 17.2) gained from the late May sowing date .

These results indicate that the leaf number/ plant of soybean significantly increased at 60 and 90 days old from sowing when soybean was planted in early May.

Such results may be due to the effect of optimum day and night temperature as well as optimum photoperiod at the early May sowing date on leaf appearance , number of nodes/plant and adequate vegetative growth period than the other two sowing dates.

In this connection, Thomas and Raper(1978), reported that night temperature is a major importance for soybean plant growth and development and affects the morphology of the crop. Board and Hall(1984),indicated that warmer temperature(27 ^{o}C) and shorter photoperiod(10 April sowing) decreased the vegetative period, Whereas lower one(21 ^{o}C) increased the vegetative period.

These results are in agreement with those reported by Eid *et al.*(1979 and 1980) and Zeiton(1983).

B)- Effect of irrigation regimes:-

Regarding to the effect of irrigation regimes on the leaf number / plant , the data listed in Table(8), show that it was significantly affected when the plants aged 60 and 90 days after planting.

The higher values of leaf number / plant at 60 and 90 days old were 20.1 and 19.9, resulted from irrigation at 1.4 accumulative pan evaporation(I_5 treatment).

The lower values of leaf number/plant at 60 days and 90 days old were 15.2 and 16.8, obtained from irrigation at 0.6 accumulative pan evaporation(I_1 treatment).

The leaf number / plant at 60 days old significantly decreased by 24.4 , 17.4 , 10.4 and 6.5 % when irrigation was applied at 0.6 , 0.8 , 1.0 and 1.2 accumulative pan evaporation, respectively, as compared with irrigation at 1.4 accumulative pan evaporation.

At 90 days old the reduction percentages were 15.2, 11.6 , 7.1 and 4.5 % for irrigation at I_1 , I_2 , I_3 and I_4 treatments, respectively,when compared with the I_5 treatment.

These results reveal that the leaf area / plant of soybean at 60 and 90 days old from sowing increased by irrigation at 1.4 accumulative pan evaporation.

These results may be due to the reduction may occure in the vegetative growth of soybean i.e.plant height and node number/plant as a result of the relation between soil moisture stress and different physiological processes occured in plants.

These results are quite expected since supplemental irrigation in short intervals enhanced vegetation growth of soybean plant.

These results are in harmony with those obtained by Eid _et al_.(1980) ; Ali(1981) and Sherif(1983).

C)- Effect of the interaction(A x B):-

The average values of **leaf number / plant** of soybean at 60 and 90 days old from sowing were not significantly affected by the interaction between sowing dates and the irrigation regime treatments , in the combined analysis of the three seasons as presented in Table(8) .

2- Leaf area / plant

The average values of leaf area / plant of soybean at 60 and 90 days after sowing as affected by sowing dates and irrigation regime treatments are presented in Table(8).

A)- Effect of sowing dates:-

The data presented in Table(8), indicate that sowing date significantly affected the leaf area/plant of soybean at 60 and 90 days old from sowing.

The higher values of leaf area/plant at 60 and 90 days old were 2764.8 cm^2. and 2924.6 cm^2/plant, resulted from sowing soybean in early May time.

The lower values of leaf area/plant at 60 and 90 days old were 2249.4 and 1599.9 cm^2, obtained from the late May sowing date.

The leaf area/plant of soybean significantly decreased at 60 days old by 11.4 and 18.6 % when soybean was planted in mid-April and late-May, respectively, over the average of the early May sowing date. Whereas, at 90 days old the reduction percentages were 4.8 and 45.3 % for mid-April and late May sowing dates, respectively.

It can be noticed that the leaf area/plant increased when soybean was planted in early May time.

These results may be due to the increase in **the leaf** number/plant , specific leaf weight, optimum temperature and solar radiation and adequate vegetative period for the early May sowing date.

In this connection, Shibles and Weber(1965), pointed out that leaf area index equal to 3.2 required 95 % of light interception and 95 % dry matter production. However, Constable(1977), indicated that a vegetative growth period of 42 to 57 days is necessary to obtain optimum leaf area index of 3.0 for higher seed yield. These vegetative period affected greatly by temperature, day length and other growing conditions.

Similar results were reported by Zeyada <u>et al</u>.(1980; Zeiton(1983) and Anderson and Vasilas(1985).

B)- <u>Effect of irrigation regimes:-</u>

Regarding to the effect of irrigation regimes on the **leaf area** /plant of soybean, the data presented in Table (8), indicate **that** irrigation regime treatments has an significant effect on **the leaf area / plant at** 60 **and** 90 days from sowing.

The highest average values of leaf **area** / plant at 60 and 90 days old from sowing were 3044.8 cm^2 and 2972.8 cm^2, respectively, produced by irrigation at 1.4 accumulative pan evaporation(I_5 treatments).

The lowest values can be noticed from the treatment I_1 i.e. irrigation at 0.6 accumulative pan evaporation.

The leaf area /plant of soybean at 60 days old from sowing significantly decreased by 8.8 , 18.5 , 27.5 and 36.9 % when water stress increased from I_5 treatment to I_4 , I_3 , I_2 and I_1 treatments , respectively.

At 90 days old from sowing the previous water stress treatments resulted in decreasing the leaf area /plant of soybean by 10.2 , 18.5 , 26.3 and 35.2 %,respectively.

It can be concluded that irrigation at 1.4 accumulative pan evaporation resulted in increasing the leaf area/plant of soybean at 60 and 90 days from sowing date.

These results may be due to the effect of the high level of available soil moisture when irrigation was applied at the wet treatment and this in turn on increasing the leaf number / plant , cell elongation, turgedity ,leaf size and activity when compared with water sressed plants.

In this respect, Kramer(1969), concluded that plants subjected to water sress not only show a reduction in the size but also exhibit modification in structure of cells, particularly of the leaf , leaf area and cell size.However, Mayaki <u>et al</u>.(1976), found that leaf area index of soybean reached its maximum value (3.9) by irrigation as compared with(2.4) for the control. Eavis and Taylor(1979),revealed that leaf area at harvesting was ranged from an average of

5400 cm^2., for the vetility water stressed plants to 11300 cm^2., per container for the high fertility watered plants.

These results are in harmony with those reported by El-Wakeel(1979) ; Reicosky et al.(1982); Heatherly(1983); Abd El-Hamid et al.(1985) and Abbas(1988).

C)- Effect of the interaction(A x B):-

Concerning to the effect of the interaction between sowing dates and irrigation regimes, the data recorded in Table(9), show that the **leaf area** /plant of soybean was significantly affected at 60 and 90 days old from sowing.

The highest value of **leaf area** /plant of soybean at 60 days old was 3235.4 cm^2, resulted from the interaction between the early May sowing date and irrigation at 1.4 accumulative pan evaporation. However, at 90 days old the highest value was 3427.2 cm^2, obtained when plants was sown in mid-April and received irrigation at 1.4 accumulative pan evaporation(D_1 x I_5 treatment).

On the other hand, the loer values of **leaf area** / plant at 60 and 90 days old were(1542.6 and 1110.8 cm^2.) resulted from irrigating soybean planted in late May at 0.6 accumulative pan evaporation(D_3 x I_1 treatment).

These results clearly show that the **leaf area** / plant of soybean at 60 days old increased by sowing in early May and irrigation at 1.4 accumulative pan **records.**

At 90 days old from sowing the leaf area /plant of soybean increased when soybean was planted in mid-April and irrigation at 1.4 accumulative pan evaporation.

These results may be due to the optimum temperature and photoperiod occured at 60 days old when soybean was planted in early May which caused the higher vegetative growth in short period than the other two sowing dates. Whereas, at 90 days old the vegetative growth decreased and the new leaves appeared at this time were small in size.

The higher values of leaves area/plant at 90 days old, resulted from sowing soybean in mid-April may be due to the nonoptimum temperature and photoperiod during the early stages of the crop development period. This resulted in increasing the vegetative growth period till the plants aged 90 days old and the growing season length increased than those planted in early May or late May sowing dates.

3- Dry weight/plant

Development changes in dry matter accumulation of plant organs during its growth cycle is often considered as a basic expression of plant growth.

Various irrigation regimes, applied under different sowing dates of soybean may lead to the better level of soil moisture which can produce maximum dry weight/plant.

The effect of sowing dates and irrigation regimes on the dry weight/plant of soybean at 60 and 90 days old from sowing, as well as at harvesting time is illustrated in Table (8).

A)- Effect of sowing dates:-

The combined analysis of variance of the three years proved that sowing dates significantly affected the dry weight/plant of soybean at 60 and 90 days old,as well as at harvesting time.

It can be noticed from the results presented in Table (8), that the dry weight/plant of soybean significantly increased as the plant age developed and reached its maximum value at harvesting time. This was true in the three sowing date treatments.

After 60 days from sowing the dry weight/plant of soybean significantly decreased by 3.8 and 12.7 % for sowing soybean in mid-April and late May sowing dates , respectively, when compared with the early May sowing date (D_2 treatment).

At 90 days old the dry weight/plant of soybean gave the same trend of 60 days old. The reduction in the dry weight/plant values were 15.8 and 23.4 % for D_1 and D_3 sowing date treatments,respectively, when compared with D_2 treatment.

At harvesting time the dry weight/plant of soybean was significantly decreased by 10.2 and 22.1 % when soybean was planted in mid-April and late May sowing date treatments,respectively,comparing to early May sowing date treatment.

The higher values of dry weight/plant of soybean were 23.6 , 44.4 and 63.7 gm., resulted from the early May sowing date at 60, 90 days old and at harvesting time , respectively.

These results reveal that the dry weight/plant or the dry matter accumulation by soybean plants increased by advancing age up to maturity.

In this connection, Shibles _et al_.(1976),indicated that seasonal dry matter exhibits essentially a linear trend between about mid-bloom and late-seed- filling . They added, that vegetation and dry weight of pods decline during later stages of seed-filling when tissues lose dry matter by respiration and mobilization to the bean fraction.

The results recorded in Table (8), prove that the highest dry weight/plant of soybean at 60 and 90 days old, as well as at harvesting time was obtained from sowing soybean in early May time.

The lower average values of dry weight/plant of soybean were 20.6 , 34.0 and 49.6 gm., at 60 , 90 days old and at harvesting time,respectively,resulted from sowing soybean in late May sowing date.

It can be concluded that the dry weight/plant of soybean increased in the early May planting. Whereas , sowing soybean three weeks earlier or later than early May resulted in decreasing significantly the dry weight/ plant at the two growth stages and at harvesting time.

In this respect, Board and Hall(1984), found that the vegetative growth period was shortened in the April 10th sowing date, whereas, the mid-May sowing date resulted in lengthening this period due to the interaction between temperature and day length at(30° N.,Lat.) and this in turn on the dry matter accumulation. Also,Seddigh and Jolliff(1984), reveiewed that a change of 5 °C in night temperature maintained over the entir growth oeriod affected markedly the vegetative and reproductive growth of some cultivars. Anderson and Vasilas(1986), indicated that dry matter accumulation rates between beginning of bloom and beginning of seed formation were high in the

May sowing date than those obtained from April and June sowing dates.

These results agree with those obtained by Eid et al. (1979) ; Galal et al.(1979) ; Zeiton(1983) ; Board and Hall(1984) and Heatherly and Elmore(1986).

B)- Effect of irrigation regimes:-

Many researches proved that the dry weight of soybean plant is a good function of soil moisture content. It is very important to know how much the soil moisture content affects the dry weight of soybean plant at the different growth stages?.

The data presented in Table(8), clearly show that the dry weight/plant of soybean after 60 and 90 days from the sowing date,as well as at harvesting time significantly affected by the different irrigation regime treatments.

The higher average values of dry weight/plant were 25.5 , 44.4 and 70.4 gm./plant, obtained at 60,90 days old and at harvesting time,respectively from irrigation at 1.4 accumulative pan evaporation.

The lower average values were 19.1 , 31.9 and 42.1 gm./plant, resulted from the irrigation regime treatment namely I_1 when the plants aged 60 , 90 days old and at harvesting time , respectively.

The results recorded in Table(8), indicated that the dry weight/plant of soybean at 60 days old significantly decreased by 4.7 , 11.9 , 18.2 and 24.5 % when irrigation was applied at I_4 , I_3 , I_2 and I_1 treatments,respectively, as compared with irrigation at I_5 treatment.

The same trend was found at 90 days old from sowing and at harvesting time. The reduction in the dry weight / plant at 90 days old were 5.7 , 12.9 , 19.9 and 28.8 % for irrigation at I_4 , I_3 , I_2 and I_1 treatments,respectively, as compared with I_5 irrigation treatment. Whereas, the dry weight/plant at harvesting time decreased by 8.7 , 18.2 , 29.7 and 40.2 % for the previous irrigation treatments , respectively, when compared with I_5 irrigation treatment.

These results revealed that the dry weight/plant of soybean at any stage of growth decreased by increasing the soil moisture stress. In other words,irrigating soybean plants in short intervals(I_5 treatment) increased the dry weight/plant.

In this connection, Kramer(1969 , concluded that the soil moisture stress resulted in reducing photosynthesis and metabolic activity processes which in turn on decreasing the dry matter production of plants. Whereas, Ashley and Ethridge(1978), showed that supplemental irrigation during the vegetative growth period produced higher dry weight/plant than irrigation started at blooming stage or at pod-filling stage. Meckel et al.(1984), found that sever water stress at the beginning of seed-filling stage caused a large reduction in soybean dry weight/plant(20.0 to 50.0 %). Ramseur et al.(1984), remarked that plants of soybean under full season irrigation accumulated 1.7 times more dry weight than the plants started irrigation at the beginning of bloom stage.

The data recorded in Table(8), proved that the dry weight/plant of soybean increased gradually as plant age developed from 60 to 90 days old and to harvesting time. These results were true for the different irrigation regime treatments.

These results are in harmony with those reported by Ashley and Ethridge(1978) ; El-Wakeel(1979) ;Boerma and Ashley(1982) ; Sherif(1983) and Abbas(1988).

C)- Effect of the interaction(A x B):-

The effect of interaction between sowing dates and irrigationn regimes on the dry weight/plant of soybean at 90 days old and at harvesting time is presented in Table (10).

The results in Table(10), indicate that the average values of dry weight/plant significantly affected due to the interaction between sowing dates and irrigation regime treatments at 90 days old and at harvesting time.

The higher values of dry weight/plant of soybean were 50.5 and 76.9 gm./plant, obtained from sowing soybean in early May and irrigation at 1.4 accumulative pan evaporation(D_2 x I_5 treatment) at 90 days old and at harvesting time, respectively.

The lower values at 90 days old and at harvesting time were 29.1 and 36.9 gm./plant,respectively,resulted from sowing soybean in late May and irrigation at 0.6 accumulative pan evaporation(D_3 x I_1 treatment).

These results may be due to the optimum day and night temperature and photoperiod during the mid-season and pod-filling stages when the plants was sown in early May time. Also, the high level of available soil moisture may resulted in increasing cell division and dry matter accumulation which in turn on increasing the weight of all plant organs i.e. leaf number/plant,plant height and stem weight. However, sowing soybean in late May time may shortened the crop development and mid-season stages time as a result of day and night temperature as well as the photoperiod effects on the dry matter accumulation. The prolonged irrigation intervals decreased the cells division and elongation as well as the hall size of the plant. This caused a sever decrease in the dry matter accumulation by soybean plants and therefore,the dry weight/plant decreased.

4- Plant height

The average values of soybean plant height(combined average of 1986 to 1988) at harvesting time as affected by sowing dates and irrigation regime treatments are presented in Table(8).

A)- Effect of sowing dates:-

The results presented in Table(8), show that sowing dates significantly affected soybean plant height at harvesting time.

The highest average value of soybean plant height was 96.1 cm., obtained from sowing soybean in mid-April sowing date, whereas, the lowest one was 49.6 cm.,resulted from sowing soybean in late May time.

The plant height at harvesting time significantly decreased by 8.5 and 15.0 % when sowing date was delayed from mid-April to early May and late May sowing dates , respectively.

These results conclude that delaying soybean sowing date after mid-April decreased the plant height at the time of harvesting.

These results may be due to the effects of day and night temperature and photoperiod occured at the three sowing dates on the number of nodes/plant,the internode length and the period of the vegetative growth.

In this respect, Beaver and Johnson(1981) , found that planting date significantly affected the main stem node number and plant height. Board and Hall(1984),show that plant height was limited by temperature and day length(photoperiod). Seddigh and Jolliff(1984),reported that plant height and node number/stem of soybean were significantly higher at warmer night temperature(16.0 °C).

These results are in full agreement with those found by Carter and Boerma(1979) ;Eid *et al.*(1979);Galal *et al.*(1979); Eid *et al.*(1980); Zeyada *et al.*(1980) ; Beaver and Johnson(1981) ; Zeiton(1983) ; Anderson and Vasilas (1985) ; Heatherly(1988) and Sultan *et al.*(1988).

B)- Effect of irrigation regimes:-

The data listed in Table (8) , show the effect of irrigation regime treatments on soybean plant height at harvesting time.

The combined analysis of variance indicated that the differences between the average values of plant height as affected by irrigation regime treatments were significant.

The maximum plant height was 70.4 cm., and the minimum one was 42.1 cm., obtained from irrigation at 1.4 and 0.6 accumulative pan evaporation, respectively.

The reduction percentages in plant height at harves time were 4.4 , 9.0 , 13.8 and 18.7 % for irrigation at

1.2 , 1.0 , 0.8 and 0.6 accumulative pan evaporation treatments , respectively, when compared with irrigation at 1.4 accumulative pan evaporation.

It can be noticed that the high available moisture level enhanced plant growth and that resulted in increasing soybean plant height. On other wards, irrigation at 1.4 accumulative pan evaporation increased soybean plant height at harvesting time

In this connection, Vaadia _et al_.(1961) and Gates (1964), pointed out that cell division appears less in sensetivity to water stress than the cell enlargement . Korte _et al_.(1983), concluded that the stem apix retains the vegetative activity during flowering and podding and that caused the semulation of stem growth with irrigation.

These results are consistent with those found by Sherif(1978) ; El-Wakeel(1979) ; Eid _et al_.(1980) ; Ali (1981) ; Boerma and Ashley(1982) ; Sherif(1983); Abbas (1988) and Heatherly(1988).

Table (8): The average values of soybean growth measurements at 60 and 90 days old as well as at harvesting time as affected by sowing dates and irrigation regime treatments. (combined analysis of three seasons)

Plant age		60 days			90 days			Harvesting time	
		Growth measurements							
Treatments		Leaf number / plant	Leaf area in cm^3/ plant	Dry weight in gm./ plant	Leaf number / plant	Leaf area in cm^3/ plant	Dry weight in gm./ plant	Dry weight in gm./ plant	Plant height in cm.
Sowing dates:									
Early	(D_1)	17.5	2477.5	22.7	18.5	2784.9	37.4	57.2	96.1
Moderate	(D_2)	18.8	2764.8	23.6	19.6	2924.6	44.4	63.7	87.9
Late	(D_3)	16.9	2249.4	20.6	17.2	1599.9	34.0	49.6	81.6
Mean		17.7	2497.2	22.3	18.4	2436.5	38.5	56.8	88.5
L.S.D.:-									
D	5 %	0.56	34.0	0.55	0.55	42.2	0.93	1.41	1.20
D	1%	0.79	47.7	0.77	0.77	59.2	1.30	1.93	1.60
Irrigation regimes:									
0.6 pan	(I_1)	15.2	1920.3	19.1	16.8	1925.2	31.9	42.1	79.6
0.8 pan	(I_2)	16.6	2261.8	20.7	17.6	2191.0	35.9	49.5	84.0
1.0 pan	(I_3)	18.0	2482.5	22.3	18.5	2423.7	39.0	57.6	88.6
1.2 pan	(I_4)	18.8	2776.7	24.1	19.0	2669.6	41.8	64.3	93.1
1.4 pan	(I_5)	20.1	3044.8	25.3	19.9	2972.8	44.8	70.4	97.4
Mean		17.7	2497.0	22.3	18.4	2436.5	38.5	56.8	88.5
L.S.D. :									
I	5 %	0.87	86.0	0.92	0.78	66.2	1.27	1.24	1.60
I	1 %	1.15	114.2	1.22	1.04	88.0	1.96	1.63	2.10
D x I	5 %	N.S.	149.0	N.S.	N.S.	114.7	2.01	2.14	N.S.
D x I	1 %	N.S.	197.9	N.S.	N.S.	152.3	2.68	2.82	N.S.

Table (9): The average values of **leaf area in cm.^{2}/ plant** of soybean as affected by the interaction between sowing dates and irrigation regime treatments.
(combined of 1986 to 1988)

Sowing date treatments		Leaf area in cm.^{2} / plant — Irrigation regimes I_1	I_2	I_3	I_4	I_5	Mean
		At 60 days old					
Early	(D_1)	1978.6	2293.0	2390.1	2739.9	2985.8	2477.5
Moderate	(D_2)	2239.6	2529.8	2798.1	3021.1	3235.4	2764.8
Late	(D_3)	1542.6	1962.6	2259.5	2568.9	2913.3	2249.4
Mean		1920.3	2261.8	2482.6	2776.6	3044.8	2497.2
L. S. D. :-							
D x I	5%						149.0
D x I	1%						197.9
		At 90 days old					
Early	(D_1)	2248.8	2461.2	2727.6	3059.8	3427.2	2784.9
Moderate	(D_2)	2415.9	2706.0	2969.1	3164.8	3367.2	2924.6
Late	(D_3)	1110.8	1406.2	1574.3	1784 .2	2124.3	1599.9
Mean		1925.2	2191.0	2423.7	2669.6	2972.8	2436.5
L.S.D. :-							
D x I	5%						114.7
D x I	1%						152.3

Table(10): The average values of dry weight in gm./plant of soybean at 60 and 90days old as well as at harvesting time as affected by the interaction between sowing dates and irrigation regimes. (combined analysis of three seasons).

Sowing date treatments		Irrigation regimes treatments					
		I_1	I_2	I_3	I_4	I_5	Mean
				At 60 days old			
Early	(D_1)	20.0	21.2	22.3	24.5	25.6	22.7
Moderate	(D_2)	20.6	21.8	23.4	25.5	26.6	23.6
Late	(D_3)	16.6	19.2	21.2	22.4	23.8	20.6
Mean		19.1	20.7	22.3	24.1	25.3	22.3
L.S.D. :							
D x I	5 %						N.S.
D x I	1 %						N.S.
				At 90 days old			
Early	(D_1)	27.8	34.7	38.9	41.6	43.6	37.4
Moderate	(D_2)	38.7	41.4	44.6	47.0	50.5	44.4
Late	(D_3)	29.1	31.6	33.7	36.9	38.9	34.0
Mean		31.9	35.9	39.0	41.8	44.3	38.5
L.S.D. :							
D x I	5 %						2.01
D x I	1 %						2.68
				At harvesting time			
Early	(D_1)	41.2	48.9	58.5	65.0	72.2	57.2
Moderate	(D_2)	48.3	55.7	65.2	72.2	76.9	63.7
Late	(D_3)	36.9	43.8	49.2	55.8	62.2	49.6
Mean		42.1	49.5	57.6	64.3	70.4	56.8
L.S.D. :							
D x I	5 %						2.14
D x I	1 %						2.82

II. Yield Components

The data presented in Table (11) , show the combined average values(1986 to 1988) of soybean yield components i.e. pod number/plant , pod weight/plant , seed number/ plant , seed weight/plant and seed index as affected by sowing dates and irrigation regime treatments.

1- Pod number/plant

A)- Effect of sowing dates:-

The average values of pod number/plant(combined of three seasons) of soybean as affected by sowing dates are recorded in Table(11).

The results in Table(11), indicated that the pod number/plant of soybean significantly affected by sowing dates.

The pod number/plant significantly decreased by 13.0 and 22.7 % when soybean was planted three weeks earlier or later than early May sowing date,respectively. Whereas, sowing soybean in late May produced 88.8 % of pod number obtained from the mid-April sowing date.

The highest value of pod number/plant was 83.1 pod, resulted from sowing soybean in early May(D_2 treatment).

The lowest value of pod number/plant was 64.2 pod , obtained from the late May sowing date(D_3 treatment).

These results indicate that pod number/plant of soybean increased when soybean was planted in early May sowing date.

These results may be due to the effect of night and day temperature and day length on the period to the first flower , flowering period , nodes number of the main stem and branches as well as plant height.

In this connection, Shibles et al.(1976) , reported that abscission of flowers and pods promoted by long day and high temperature. Also, they reviewed that the light stress reduced pod setting by 57.0 to 71.0 %, whereas , cool temperature of 15.0 ^{o}C., for two weeks before bloom severly reduced pod setting. Thomas and Raper(1978),found that a 4.0 ^{o}C.,increase in night temperature from 14.0 ^{o}C., to 18.0 ^{o}C.,dubled the pod number of soybean cv. Ransom when the day temperature was kept constant at 22.0 ^{o}C. Seddigh and Jolliff(1984), revealed that the final number of pods/plant was the seed yield component least affected by night temperature. Board(1985), indicated that the decrease in branch fertile nodes were related to the pods number reduction of branches at nonoptimal sowing dates of April or June.

These results are in harmony with those reported by Carter and Boerma(1979) ; Eid et al.(1979); Galal et al. (1979) ;Nigem(1981(; Anderson and Vasilas(1985); Board (1985) ; Eweida et al.(1986) and Sultan et al.(1988)

B)- Effect of irrigation regimes:-

Regarding to the effect of irrigation regimes on the pod number/plant of soybean, the data presented in Table (11), reveal that the pod number / plant significantly affected by irrigation regime treatments.

The highest value of pod number/plant was 86.9 pods, obtained from irrigation at 1.4 accumulative pan evaporation.

The lowest value of pod number/plant was 58.1 pods , scored from irrigation at 0.6 accumulative pan records.

Irrigation at 1.2 , 1.0 , 0.8 and 0.6 accumulative pan evaporation resulted in decreasing the pod number / plant by 7.1, 15.0, 23.5 and 33.1 %, respectively, when compared with irrigation at 1.4 accumulative pan records.

These results concluded that keeping the soil wet by irrigation at 1.4 accumulative pan evaporation caused an increase in the pod number/plant of soybean.

These results may be due to the effect of high soil moisture level on the plant height ,node number/branch and stem, dry matter accumulation and flower number / plant.

In this respect, Sionit and Kramer(1977) , indicated that the smallest number of pods/plant was resulted from the plants, subjected to water stress during early pod formation. They added, that water stress during flowering caused decreases in the flowering period and the number of flowers, as well as less pods number as a result of the flowers abortion. Ashley and Ethridge(1978), pointed out that full season irrigation significantly increased the pod number/plant than beginning irrigation at late stages and the loss of pods during the late reproductive stages became more evidant with increasing the irrigation numbers.

These results are consistent with those reported by Sherif(1978) ; El-Wakeel(1979) ; Eid _et al_.(1980); ; Carlson _et al_.(1982) and Abbas (1988).

C)- Effect of the interaction(A x B):-

The average values of the pod number / plant of soybean were not significantly affected by the interaction between sowing dates and irrigation regime treatments in the combined analysis of the three seasons as presented in Table(11).

2- Pod weight/plant

Data recorded in Table(11), represent the effect of sowing dates and irrigation regimes on the pod weight / plant of soybean.

A)- Effect of sowing dates:-

The combined averages of the three seasons(1986 to 1988),presented in Table(11), reveal that the pod weight/ plant of soybean significantly affected by sowing dates.

The highest value of pod weight/plant was 44.4 gm., obtained from sowing soybean in early May time, whereas , the lowest one was 32.0 gm., resulted from sowing soybean in late May sowing date.

The pod weight/plant significantly decreased by 6.9 and 12.4 gm./plant when soybean was planted three weeks early or later than the early May sowing date,respectively.

The pod weight/plant of soybean, planted in mid-April time increased by 5.5 gm./plant over that resulted from sowing soybean in late May time.

These results may be due to the pod number / plant, and the effect of temperature and day length on the dry matter accumulation by plants.

In this connection, Kollman et al.(1974),found that any decrease in the sink-source ratio decreased the dry matter translocation, particularly soluble carbohydrates to the sink. Thomas et al.(1981), showed that the dry matter accumulation in pods was greatly affected by the night temperature than by the day temperature.

These results agree with that reported by Eid et al. (1979).

B)- Effect of irrigation regimes:-

The data listed in Table(11), clearly show that the pod weight/plant of soybean significantly affected by irrigation regime treatments.

The highest value of pod weight/plant was 47.2 gm., obtained when soybean plants received I_5 treatment.

The lowest value of pod weigh/plant was 28.1 gm., resulted from I_1 irrigation regime treatment.

The pod weight/plant significantly decreased by 40.5 % when irrigation was applied at 0.6 accumulative pan evaporation,as compared with that resulted from irrigation at 1.4 accumulative pan evaporation.

These results emphasize that the pod weight/plant of soybean decreased gradually as water stress increased.

Such results may be due to the effect of water stress during soybean life cycle on the pod number/plant and the dry matter accumulation in pods.

In this order, Hsiao and Acevedo(1974), stated that the decrease in the dry matter translocation during water stress was due to the reduction in source strength by reducing photosynthesis and reducing sink strength by inhibiting growth. Sionit and Kramer(1977), pointed out that water stress at the pod filling stage resulted in shortining the maturation period and the pods was ripened about one week earlier than nonstressed plants and this in turn on decreasing the dry matter accumulation in the pods.

These results are in full agreement with those found by Sherif(1978); El-Wakeel(1979) ; Ali(1981) and Abbas (1988).

C)- Effect of the interaction(A x B):-

The average values of pod weight/plant of soybean as affected by the interaction between sowing dates and irrigation regime treatments are presented in Table(12).

The combined average over seasons,recorded in Table (12), reveal that the pod weight/plant significantly affected by the interaction between soybean sowing dates and irrigation regime treatments.

The highest value of pod weight/plant was 54.2 gm., resulted from the interaction between sowing in early May time and irrigation at 1.4 accumulative pan evaporation (D_2 x I_5).

The lowest value of pod weight/plant was 23.6 gm., obtained from sowing soybean in late May and irrigation at 0.6 accumulative pan evaporation(D_3 x I_1 treatment).

These results may be due to the effect of the high level of available soil moisture,resulted from the short irrigation intervals under the optimum temperature and photoperiod of the early May sowing date. This effects may be in turn on increasing the vegetative period, dry matter accumulation, flowering period and pod number / plant.

It can be concluded that sowing soybean in early May and irrigation at 1.4 accumulative pan evaporation increased the pods weight/plant.

In this respect, Eid et al.(1980), found that short irrigation intervals of 7 days for soybean planted in the early of May increased the pod number and weight/plant. Heatherly(1988), reported that supplemental irrigation to soybean planted in early May increased yield components when compared with irrigation applied to the plants,sown in early June.

3- Seed number/plant

The effect of sowing dates and irrigation regimes on seed number/plant of soybean is presented in Table(11).

A)- Effect of sowing dates:-

Data listed in Table(11), show that the averages of seed number/plant of soybean significantly affected by sowing dates .

Seed number/plant significantly decreased by sowing soybean three weeks before or after early May sowing date.

The maximum and the minimum values of seed number/plant were 182.1 and 123.2, resulted from early and late May sowing dates , respectively .

The combined average values over seasons recorded in Table(11),show that the reduction percentages in seed number/plant were 10.6 and 32.3 % when soybean was sown three weeks earlier or later than early May sowing date , respectively .

It can be concluded that sowing soybean in early May increased the seed number/plant .

These results may be due to the increase in number of pods/plant, as well as the effect of temperature and photoperiod on the number of ovules/pod.

In this connection, Seddigh and Jolliff(1984),found that seed number/plant increased at night temperature higher than 16 °C due to the increase in pod number / plant and seed number/pod. Anderson and Vasilas (1985), pointed out that delaying sowing date after May 12 time decreased the seed number/plant . Board(1985), indicated that nonoptimal sowing date resulted in reducing number of pods/branch for the plants sown on April or June , and this in turn gave fewer seeds number/plant

These results are consistent with those obtained by Zeyada _et al_.(1980) ; Negim(1981) ; Zeiton(1983); Sarmah and Choudhury(1984) ; Anderson and Vasilas(1985); Board (1985) ; Eweida _et al_.(1986) and Heatherly(1988) .

B)- Effect of irrigation regimes:-

Data in Table(11), clearly show that seed number/ plant of soybean was significantly affected by different irrigation regime treatments .

The results presented in Table(11), reveal that increasing water stress to long intervals caused significant decreased in the seed number/plant of soybean .

The maximum and minimum values of seed number/plant of soybean were 186.2 and 123.4, obtained from irrigation at 1.4 accumulative pan evaporation , respectively .

Increasing soil moisture stress more than irrigation treatment namely I_5 to I_4 , I_3 , I_2 and I_1 treatments resulted in decreasing seed number/plant of soybean by 6.8 , 15.9 , 25.0 and 33.7 % , respectively .

It can be mentioned that water stress during growth period of soybean plants decreased the seed number / plant.

These results might be due to the reduction in pod number/plant under water stress conditions and abortion of flowers and pods.

In this connection, Sionit and Kramer(1977), stated that the lowest number of seeds/plant was resulted from the plants subjected to water stress during the early of pod formation period . Momen et al.(1979),pointed out that the reduction occured in seed number/plant due to water stress resulted from seed abortion during the seed filling period. However, Ramseur et al.(1984),emphasized that the increase in seed number/plant under irrigation treatments resulted from the increase in pod number / plant and seed /pod when compared with water stress and nonirrigated treatments .

These results agree with those found by Sherif(1978); El-Wakeel(1979) ; Ali(1981) ; Carlson et al.(1982);Sherif (1983) ; Heatherly(1986) ; Abbas(1988) and Heatherly(1988).

C)- Effect of the interaction(A x B):-

The data presented in Table(11) , show that the average values(combined of three seasons) of the number of seeds/plant of soybean were not significantly affected by the interaction between sowing dates and the irrigation regime treatments.

4- Seed weight / plant

The data presented in Table(11) , show the effect of soybean sowing dates and irrigation regime treatments on the seed weight/plant

A)- Effect of sowing dates:-

The combined average values of the three seasons of seed weight/plant of soybean as affected by sowing dates are recorded in Table(11).

The results listed in Table(11) , emphasized that sowing dates significantly affected the seed weight/plant of soybean.

The highest value of seed weigh/plant was 27.5 gm., resulted from the early May sowing date. However, the lowest one was 17.7 gm., obtained from the late May sowing date treatment.

The seed weight/plant significantly reduced by 13.8 and 35.6 % when soybean was sown three weeks earlier or later than D_2 treatment , respectively .

These results conclude that the seed weight/plant of soybean increased when soybean was planted in early May time .

Such results may be due to the higher **number** of seed /plant, more dry matter accumulation in seeds and higher weight of pods/plant resulted from the early May sowing date .

In this respect, Seddigh and Jolliff(1984), reported that low night temperature restricted soybean seed growth rate and favoe partitioning of photosynthates to vegetative organs and pod wall. They added, that high night temperature above 16 ^{o}C caused a slight decrease in seed weight/plant. Anderson and Vasilas(1985), indicated that the rate of seed dry matter accumulatin during the period of seed-filling was decreased when sowing date delayed after May 10th . Board(1985), found that seed weight of branches was decreased when soybean was planted in April or June time when compared with May sowing date .

These results in good agree with those scored by Eid et al.(1979) ; Galal et al.(1979) ; Eid et al.(1980); Zeyada et al.(1980) ; Nigem(1981) ; Zeiton(1983);Eweida et al.(1986) and Heatherly(1988) .

B)- Effect of irrigation regimes:-

Data illustrated in Table(11), indicate that average values of seed weight/plant of soybean was significantly affected by irrigation regime treatments .

The averages of combine over three years listed in Table(11), proved that seed weight/plant of soybean was significantly decreased as soil moisture stress increased.

The highest value of seed weight/plant was 29.4 gm., obtained from irrigation at 1.4 accumulative pan evaporation(I_5) .

The lowest value was 16.3 gm.,resulted from applying irrigation at 0.6 accumulative pan evaporation(I_1) .

The reduction percentages in seed weight/plant were 10.3 , 21.8 , 33.7 and 44.6 %,resulted from increasing the irrigation regimes to I_4 , I_3 , I_2 and I_1 treatments , respectively, as compared with I_5 treatment .

These results revealed that seed weight/plant of soybean increased when irrigation applied at 1.4 accumultive pan evaporation .

These results may be due to the high number of seeds/plant , more dry matter accumulation in seeds during the reproductive stages and seed growth rate resulted from the high levels of available soil moisture .

In this respect, Meckel *et al.*(1984), reported that water stress during reproductive stage resulted in decreasing the seed growth rate and shortened the duration of seed-filling period . Ramseur *et al.*(1984), pointed out that full season irrigation increased the single seed weight, whereas , water stress during reproductive stage affected more the single seed weight than water stress occured during the early floweing stage .

Thse results are in full agree with those indicated by Sherif(1978) ; El-Wakeel(1979) ; Eid *et al.*(1980) ; Sherif(1983) ; Heatherly and Elmore(1986) ; Abbas(1988) and Heatherly(1988) .

C)- Effect of the interaction(A x B):-

The results presented in Table(11),reveal that the average values of seed weight/plant of soybean were not significantly affected by the interaction between sowing dates and irrigation regime treatments in the combined analysis of the three seasons (1986 to 1988) .

5- Seed index

The effect of soybean sowing dates and irrigation regime treatments on seed index(100-seed weight in gm.) are presented in Table(11) .

A)- Effect of sowing dates:-

The combined average values recorded in Table(11) , show that soybean seed index significantly affected by the different treatments of sowing dates .

The highest value of soybean seed index was 15.0 gm., resulted from sowing soybean in early May , whereas the the lowest one was 13.9 gm., obtained from the late May sowing date .

The seed index significantly decreased by 4.7 % and 7.3 % when soybean was planted in mid-April and late May, respectively, as compared with the earl May sowing date.

These results revealed that seed index increased by sowing soybean in early May .

These results may be attributed to the effect of the optimum night temperature and day length during early May sowing date treatment on dry matter accumulation in seeds.

In connection of these results, Egli and Wardlaw (1980), found that soybean seed growth was influenced by temperature through a dirict effect on seed metabolism as well as on other growth processes. Whereas,E gli et al. (1981), reported that seed size was infuenced by both genetic and environmental factors. Also, Seddigh and Jolliff(1984), indicated that seed growth was restricted by a dirict effect of low night temperature and partitioning of photosynthetase to vegetative organs and pods wall was favored. Anderson and Vasils(1985), showed that changes in harvest index was affected by the alternation in the vegetative and reproductive phasis duration which brought out by differences in sowing dates

These results are agree with those reported by Eid et al.(1979) ; Zeiton(1983) and Anderson and Vasilas(1985).

B)- Effect of irrigation regimes:-

The average values of seed index of soybean as affected by different irrigation regime treatments are listed in Table(11) .

Data recorded in Table(11), proved that irrigation regime treatments had a significant effect on soybean seed index .

The highest value of seed index was 15.5 gm.,resulted from irrigation at 1.4 accumulative pan evaporation rate. Whereas, the lowest value was 12.9 gm., resulted from irrigation at 0.6 accumulative pan evaporation .

The average values of soybean seed index in gm.,was significantly decreased by 3.2 , 6.5 , 9.7 and 16.8% when irrigation was practiced at 1.2 , 1.0 , 0.8 and 0.6 of accumulative pan evaporation records, respectively , as compared with irrigation at 1.4 accumulative evaporation.

These results may be due to the effect of moisture stress on the dry matter translocation as a result of photosynthesis reduction which reflects on inhibiting growth and producing small seeds .

In this respect, Ashley and Ethridge(1978), indicated that seed size obtained from nonirrigated plants was smaller than those obtained from plants received irrigation at any stage of plant development . Whereas,Ramseur et al. (1984), found that full season irrigation significantly increased the single seed weight of soybean than beginning irrigation at bloom or nonirrigated plants .

It can be concluded that frequent irrigation increased the seed index of soybean plant . In other words , irrigation in short intervals i.e. at 1.4 accumulative pan evaporation increased soybean seed index .

These results are consistent with those reported by Sherif(1978) ; Ali(1981) ; Carlson et al.(1982);Sherif (1983) and Abbas(1988) .

C)- Effect of the interaction(A x B):-

The average values of seed index of soybean were not significantly affected by the interaction between sowing dates and irrigation regime treatments .

Table (11): The average values of soybean yield components as affected by sowing dates and irrigation regimes. (combined of three seasons).

Treatments		Yield components				
		Pod number/ plant	pod weight in gm./ plant	seed number/ plant	seed weight in gm./ plant	seed index in gm.
Sowing dates:						
Early	(D_1)	72.3	37.5	162.8	23.7	14.3
Moderate	(D_2)	83.1	44.4	182.1	27.5	15.0
Late	(D_3)	64.2	32.0	123.2	17.7	13.9
Mean		73.2	38.0	156.0	23.0	14.4
L. S. D.:-						
Sowing dates	5 %	1.86	1.04	5.54	0.34	0.28
	1 %	2.54	1.43	7.59	0.50	0.39
Irrigation regimes:						
0.6 pan	(I_1)	58.1	28.1	123.4	16.3	12.9
0.8 pan	(I_2)	66.5	33.3	139.7	19.5	14.0
1.0 pan	(I_3)	73.9	38.3	156.6	23.0	14.5
1.2 pan	(I_4)	80.7	42.9	173.5	26.4	15.0
1.4 pan	(I_5)	86.9	47.2	186.2	29.4	15.5
Mean		73.2	38.0	156.0	23.0	14.4
L. S. D. :-						
Irrigation regimes	5%	1.65	1.05	4.50	0.27	0.39
	1%	2.18	1.38	5.95	0.36	0.51
D x I	5%	N.S.	1.81	N.S.	N.S.	N.S.
D x I	1%	N.S.	N.S.	N.S.	N.S.	N.S.

Table (12): The average values of pod weight in gm./plant of soybean as affected by the interaction between sowing dates and irrigation regime treatments.
(combined of 1986 to 1988 seasons).

		Pod weight in gm./plant					
		Irrigation regimes					
		I_1	I_2	I_3	I_4	I_5	Mean
Early	(D_1)	26.9	33.4	37.9	42.5	46.6	37.5
Moderate	(D_2)	33.7	38.8	45.3	50.1	54.2	44.4
Late	(D_3)	23.6	27.7	31.6	36.1	40.9	32.0
Mean		28.1	33.3	38.3	42.9	47.2	38.0
L. S. D. :							
Interaction	5%						1.81
D x I	1%						N.S.

III. Seed yield

The average values of soybean seed yield expressed as kg./faddan in 1986 , 1987 and 1988 seasons as well as the combined average of the three seasons as affected by sowing dates and irrigation regime treatments are listed in Table(13) .

The combined analysis of variance proved that each of years , sowing dates , irrigation regimes and the interaction between years , sowing dates and irrigatin regimes were significantly affected soybean seed yield.

The statistical analysis of variance indicated that the effect of sowing dates and irrigation regimes on the yield of soybean seeds was significantly differed from one year to another .

A)- Effect of sowing dates:-

The data recorded in Table(13), show that the average values of soybean seed yield(combine over three seasons) were significantly affected by sowing dates .

The maximum average value of soybean seed yield as a combine over seasons was 2079.9 kg./faddan, resulted from sowing soybean in early May time

The minimum average value(combined of three seasons) of soybean seed yield was 1446.1 kg./faddan , obtained from the late May sowing date(D_3) .

The combined average values of soybean seed yield significantly decreased by 7.9 and 29.5 % when soybean was planted three weeks earlier or later than early of May sowing date, respectively .

The same trend of these results was found during 1986 , 1987 and 1988 seasons .

It can be concluded that sowing soybean in early May gave the highest value of seed yield /faddan .

It is clear that the increase in the seed yield / faddan may be resulted from the increase in leaf area/ plant , dry weight/plant, high pod and seed number / plant , high pod and seed weight/plant and the higher seed index resulted from sowing soybean in early May .

In this connection, Beaver and Johnson(1981),found that seed yield of indeterminate cultivars was decreased linearly with delaying sowing date to past early May . Whereas, Parker et al.(1981),reported that the increase in seed number/plant was the main reason in producing the maximum yield when soybean was planted in early May, as compared with the early April or June sowing dates . Also, Board and Hall(1984), concluded that the warmer temperature under short day decreased the vegetative period of soybean plant than under long day which in turn resulted in decreasing seed yield . Seddigh and

Jolliff(1984), pointed out that warm night temperature significantly increased seed yield than colder one . Board(1985), indicated that the seed yield reductions resulted from the early-April or mid-June sowing dates due to the decrease in seeds weight of branches/plant .

These results are consistent with those obtained by Eid et al.(1979) ; Carter and Boerma(1979); Eid et al. (1980) ; Beaver and Johnson(1981) ; Zeiton(1983); Board and Hall(1984) ; Sarmah et al.(1984) ; Anderson and Vasilas(1985) ; Board(1985) ; Paul et al.(1985);Eweida et al.(1986) ; Heatherly and Elmore(1986);Singh et al. (1987) and Heatherly(1988) .

Effect of years:

Regarding to the effect of years on soybean seed yield under the different sowing dates the data are presented in Table(13) .

The combined analysis of variance proved that the average values of soybean seed yield resulted from the different sowing dates i.e. D_1 , D_2 and D_3 treatments significantly differed from year to year .

The higher average values of soybean seed yield were 2252.5 , 2433.5 and 1874.8 kg./faddan, resulted in 1988 season for D_1 , D_2 and D_3 sowing date treatments, respectively . However, the seed yield in 1986 and 1987 seasons were lower than 1988 season .

In 1986 season the reduction percentages in seed yield were 19.6 , 19.1 and 31.5 % for D_1, D_2 and D_3 sowing date treatments,respectively, as compared with the same tratments in 1988 season .

In 1987 season more reduction occured in seed yield than 1986 season . The seed yield in 1987 season reduced by 25.3 , 24,5 and 33.9 % for D_1 , D_2 and D_3 treatments, respectively, when compared with the same treatments in 1988 season .

The average values of soybean seed yield over all sowing dates in 1988 season was higher than those resulted in 1986 and 1987 seasons by 21,8 and 27.5 %, respectively.

These results may be due to the higher values of air temperature , higher solar radiation occured during the vegetative growth period and reproductive stage in 1988 season than the other two years (Tables , 5,6 and7).These higher climatic factors may enhanced the vegetative growth of soybean plants and leaf area/plant which caused more dry matter accumulation in all plant organs. Some of the seed yield reduction occured in 1987 season may be due to the high infection by some of the cotton insects.

These results agree with those found by Board and Hall(1984) and Seddigh and Jolliff(1984) who reported that years differed significantly in their effect on soybean seed yield.

B)- Effect of irrigation regimes:-

The average values of soybean seed yield(combined of 1986 to 1988) as affected by irrigation regime treatments are scored in Table(13) .

The combined analysis of variance indicated that irrigation regimes significantly affected the average values of soybean seed yield.

The highest average value(combined of three seasons) of soybean seed yield was 2118.6 kg./faddan,resulted from irrigation at 1.4 accumulative pan evaporation .

The lowest average value was 1431.4 kg./faddan,obtained from irrigation at 0.6 accumulative pan evaporation.

The average values of soybean seed yield(combined of three seasons) significantly decreased by 5.2 , 11.4, 21.3 and 32.4 % when soil moisture stress increased gradually from I_5 treatment to I_4 , I_3 , I_2 and I_1 treatments, respectively .

The data presented in Table(13), indicate that the average values of soybean seed yield as affected by the irrigation regime treatments during 1986 , 1987 and 1988 seasons gave the same trend of the combined of the three years .

It can be revealed that short irrigation intervals i.e.irrigation at 1.4 accumulative pan evaporation gave the highest soybean seed yield/faddan .

These results may be due to the increase in plant height , leaf area/plant , dry weight/plant ,pod and seed number/plant , pod and seed weight/plant and seed index, resulted from the high available soil moisture level(irrigation at 1.4 accumulative pan evaporation) .

In the same manner, Hsiao and Acevedo(1974),attributed the decrease in translocation of dry matter during water stress to the reduction in source strength by reducing photosynthesis and reducing sink strength by inhibiting growth . Sionit and Kramer(1977),found that water stress reduced leaf surface and translocation of dry matter to the seeds may have also been slowed, and caused a significant reduction in the total weight and number of seeds . Carlson et al.(1982), indicated that seed /pod and pod number/node decrements were contributed to yield reduction of soybean. Meckel et al.(1984), revealed that seed size significantly reduced by water stress as well as the duration of seed-filling period . Ramseur et al.(1984), emphasized that seeds number and single seed weight are the two yield components which determine soybean seed yield.They also added,that the increase in seed number by supplemental irrigation was the source of higher seed yield and the seed number was highly correlated with seed yield .

The results mentioned above agree with those obtained by Ashley and Ethridge (1978) ; Cassel et al.(1978) ; El-Wakeel(1979) ; Eid et al.(1980) ; Ali(1981);Snyder et al.(1982) ; Jennifer et al.(1983) ; Ramseur et al.(1984) ; Abbas(1988) and Heatherly(1988) .

Effect of years:

The data presented in Table(13), show that the average values of soybean seed yield as affected by irrigation regime treatments significantly differed from year to another.

The higher values were obtained from 1988 season and the lower ones were obtained from 1987 season .

The seed of soybean increased by 29.3 , 32.3 , 27.6, 25.0 and 24.4 % for I_1 , I_2 , I_3 ,I_4 and I_5 ,treatments , respectively in 1988 season than the same treatments in 1987 season . The increase of seed yield in 1988 season were 20.8 , 23.6 , 23.8,23.5 and 21.8 % for I_1 , I_2 , I_3, I_4 and I_5 irrigation treatments ,respectively,as compared with the averages of 1986 season .

These results may be due to the effect of high values of temperature and solar radiation during the vegetative growth period which in turn on increasing the absorption of water causing more cell division,more cell enlargement, more dry matter accumulation,larger leaf area,higher yield components than the other two seasons. Also, these results may be due to the effect of the preceeding crop in 1988 when compared with 1986 and 1987 seasons , Table(4) .

These results are in agreement with those found by Boerma and Ashley(1982) ; Korte et al.(1983) ; Heatherly and Elmore(1986) and Heatherly(1988) .

C)- Effect of the interactions:-

i)- Effect of the interaction(A x B):-

The average values of soybean seed yield as affected by the interaction between sowing dates and irrigation regime treatments in 1988 season are presented in Table (14) .

The results listed in Table(14),reveal that the average values of soybean seed yield significantly affected by the interaction between sowing dates and irrigation regime treatments in 1988 season only .

The highest average value of soybean seed yield was 2854.4 kg./faddan, resulted from the early May sowing date and irrigation at 1.4 accumulative pan evaporation .

The lowest average value of soybean seed yield was 1605.4 kg./faddan, obtained from the late May sowing date and irrigation at 0.6 accumulative pan evaporation .

The average values of soybean seed yield decreased by 8.0 , 3.2 , 6.6 , 8.6 and 9.1 % when received irrigation at I_1 , I_2 , I_3 , I_4 and I_5 treatments for plants sown in mid-April sowing date,as compared with the same irrigation treatments of the early May sowing date .

Sowing soybean in late May time and irrigation at I_1, I_2 , I_3 , I_4 and I_5 treatments resulted in decreasing seed yield/faddan by 13.2 , 17.1 , 25.2 , 27.5 and 26.8 % , respectively, over the same irrigation treatments of early May sowing date .

It can be concluded that sowing soybean in early May and keeping the soil in high level of available moisture caused an increase in the seed yield .

These results may be due to the high values of the climatic demands occured in 1988 season than those in 1986 and 1987 seasons,i.e. night and day temperature and net radiation received during the vegetative growth period and mid-season of soybean plants as well as the effect of high level of available soil moisture in increasing plant growth .

ii)- <u>Effect of the interaction (A x B xyears):-</u>

The data presented in Table(15), show the average values of soybean seed yield as affected by the interaction between sowing dates , irrigation regime treatments and years in the combined analysis of three seasons .

The results listed in Table(15), indicate that the average values of soybean seed yield was significantly -

affected by the three variables interaction(combined of three seasons) .

The highest average value of soybean seed yield , resulted from sowing soybean in early May and irrigation at 1.4 accumulative pan evaporation which was recorded in 1988 season .

The lowest average value of seed yield was obtained from sowing soybean in late May and irrigation at 0.6 accumulative pan evaporation in 1987 season .

These results may be due to the effect of high values of climatic factors during 1988 season on increasing the vegetative and reproductive growth of soybean plants and also, the effect of irrigation at high soil moisture levels which enhanced growth and increased yield and yield components. In 1987 season sowing soybean in late May time and water stress throughout the growing season as well as the infection occured by cotton insects resulted in decreasing the growth measurements , yield components and seed yield (Tables : 8 , 11 and 13).

Table (13): The average values of soybean seed yield as affected by sowing date and irrigation regime treatments in 1986 , 1987 and 1988 seasons , as well as the combined over years.

Treatments		Seed yield in kg./faddan			
		1986	1987	1988	Combined (1986 to 1988)
Sowing dates:					
Early	(D_1)	1811.2	1683.6	2252.5	1915.8
Moderate	(D_2)	1969.5	1836.7	2433.5	2079.9
Late	(D_3)	1284.9	1238.7	1874.8	1466.1
Mean		1688.5	1586.4	2186.9	1820.6
L.S.D. :					
Years(Y)	5 %				45.6
	1 %				62.6
Sowing	5 %	131.4	48.7	75.9	45.6
dates	1 %	199.1	73.7	115.0	62.6
Irrigation regimes:					
0.6 pan	(I_1)	1360.6	1215.0	1718.6	1431.4
0.8 pan	(I_2)	1565.4	1387.9	2049.1	1667.5
1.0 pan	(I_3)	1725.8	1639.1	2265.0	1876.6
1.2 pan	(I_4)	1832.6	1797.7	2396.6	2008.9
1.4 pan	(I_5)	1958.4	1892.2	2505.3	2118.6
Mean		1688.5	1586.4	2186.9	1820.6
L.S.D. :					
Irrigation	5%	83.2	91.0	128.8	58.1
rregimes	1%	111.6	122.0	172.9	76.6
D x I	5%	N.S.	N.S.	223.1	N.S.
D x I	1%	N.S.	N.S.	N.S.	N.S.
D x I x Y	5%	N.S.	N.S.	N.S.	174.4
D x I x Y	1%	N.S.	N.S.	N.S.	N.S.

Table (14): The average values of soybean seed yield as affected by the interaction between sowing dates and irrigation regime treatments in 1988 season.

Sowing date treatments		Seed yield in kg./faddan					
		Irrigation regimes					
		I_1	I_2	I_3	I_4	I_5	Mean
Early	(D_1)	1701.3	2134.3	2365.7	2489.4	2571.7	2252.5
Moderate	(D_2)	1849.0	2205.1	2534.7	2724.7	2854.4	2433.5
Late	(D_3)	1605.4	1808.0	1895.1	1975.6	2089.8	1874.8
Mean		1718.6	2049.1	2265.0	2396.6	2505.3	2186.9
L. S. D. :							
Interaction D x I	5%						223.1
	1%						N.S.

Table (15): The average values of soybean seed yield as affected by the interaction between, sowing date, irrigation regimes and years.

Sowing date treatments	Seed yield kg./faddan					
	Irrigation regimes					
	I_1	I_2	I_3	I_4	I_5	Mean
			1986			
Early (D_1)	1463.2	1683.2	1843.5	1953.5	2112.6	1811.2
Moderate (D_2)	1633.8	1810.9	2003.0	2139.4	2260.6	1969.5
Late (D_3)	984.9	1202.0	1330.8	1405.0	1501.9	1284.9
Mean	1360.6	1565.4	1725.8	1832.6	1958.4	1688.5
			1987			
Early (D_1)	1341.6	1504.8	1747.5	1860.0	1964.2	1683.6
Moderate (D_2)	1500.8	1705.2	1890.0	1987.2	2100.5	1836.7
Late (D_3)	802.7	953.8	1279.8	1545.8	1611.9	1238.7
Mean	1215.0	1387.9	1639.1	1797.7	1892.2	1586.4
			1988			
Early (D_1)	1710.3	2134.3	2365.7	2489.4	2571.7	2252.5
Moderate (D_2)	1849.0	2205.1	2534.2	2724.7	2854.4	2433.5
Late (D_3)	1605.4	1808.0	1895.1	1975.6	2089.8	1874.8
Mean	1718.6	2049.1	2265.0	2396.6	2505.3	2186.9
			Combined (1986 to 1988)			
Early (D_1)	1502.0	1774.1	1985.6	2101.0	2216.2	1915.8
Moderate (D_2)	1661.2	1907.1	2142.4	2283.8	2405.2	2079.9
Late (D_3)	1131.0	1321.3	1501.9	1642.0	1734.5	1466.1
Over all mean	1431.4	1667.5	1876.6	2008.9	2118.6	1820.6

L. S. D. :-

D x I x Years	
5 %	174.4
1 %	—

IV. Chemical Properties of Seeds

The results presented in Table(16), show the combined average values(1986 to 1988) of some chemical properties of soybean seeds i.e.oil percentage , oilyield in kg. / faddan , protein percentage and protein yield in kg./fadd., as affected by sowing dates and irrigation regimes.

1- Oil percentage of seeds

A)- Effect of sowing dates:-

The average values of oil percentage in soybean seed (combined average over the three seasons) as affected by sowing dates are presented in Table(16).

The results in Table(16), reveal that the oil percentage in soybean seeds significantly affected by sowing dates.

The highest average value of oil percentage in seeds was 25.3 %, obtained from the mid-April sowing date.

The lower average value of oil percentage in seeds was 22.3 %, resulted from sowing soybean in late May.

The oil percentage in soybean seeds significantly decreased by 5.1 and 11.9% when soybean sowing date was delayed from mid-April to early and late May treatments, respectively,(in the combined analysis of three seasons).

It can be concluded that the oil percentage in seeds decreased by delaying soybean sowing date after the mid-April time.

These results may be due to the effect of high day and night temperature during seed development **on the** translocation of carbohydrate content of seeds to fatty acids.

In this connection, Howell and Carter(1958),reported that the relatively high temperature increase fat content appreciably without much influence on protein content . They also, added that the maximum effect of high day temperature begins during the earlier phase of seed development and continues until half maximum seed weight is reached. Saito(1961), found a similar relationship between day temperature and fat content of soybean seed.

These results are in good agreement with those found by Essmail(1978) ; Galal et al.(1979);**Beatty et al.(1982)** and Eweida et al.(1986).

B)- Effect of irrigation regimes:-

The data presented in Tanle(16), show that irrigation regime treatments had a significant effect on the average values of oil percentage in soybean seeds.

The highest average value of oil percentage in seeds was 25.4 %, obtained from irrigation at 1.4 accumulative pan evaporation.

The lowest average value of oil percentage in seeds was 22.4 %, resulted from irrigation applied to soybean at 0.6 accumulative pan evaporation(I_1 treatment).

The oil percentage in seeds significantly decreased by 2.8 , 6.3 , 9.4 and 11.8 % when irrigation was applied at 1.2 , 1.0 , 0.8 and 0.6 accumulative pan evaporation, respectively,(in the combined analysis of three seasons).

These results emphasize that the oil percentage in seeds of soybean increased as irrigation intervals reduced i.e. irrigation at 1.4 accumulative pan evaporation.

These results may be due to the accumulation of fat during the development of storage organs(seeds), resulted from sugar transformation to fatty acids.

In this respect, Kramer(1977), reported that water stress caused a considerable decrease in the organic compounds translocation in the plants. Sherif(1983),pointed out that fats increased in quality and concentration rate during the development of soybean seeds, and such increase is probably due to fat performance from sugar content in seeds.

These results are in full agreement with those found by Sherif(1978) ; El-Wakeel(1979); Ali(1981);Sherif(1983) and Abbas(1988).

C)- Effect of the interaction(A x B):-

The average values(combined of three seasons)of the oil percentage in soybean seeds were not significantly affected by the interaction between sowing dates and irrigation regime treatments as presented in Table(16) .

2- Oil yield in kg./faddan

The average values of oil yield in kg. / faddan of soybean(combined of three seasons) as affected by sowing dates and irrigation regime treatments are presented in Table(16).

A)- Effect of sowing dates:

The combined average values of the three seasons presented in Table(16), show that the oil yield of seeds significantly affected by soybean sowing dates.

The highest average value of oil yield of soybean was 503.5 kg./faddan, resulted from sowing soybean in early May(D_2 treatment).

The lowest average value of soybean oil yield was 490.6 kg./faddan, obtainrd from the mid-April sowing date.

The oil yield of soybean seeds significantly decreased by 2.6 and 34.3 % when soybean was planted three weeks before or after early May sowing date ,respectively.

It can be reveal that sowing soybean in early May time resulted in increasing the oil yield of seeds.

These results may be due to the higher seed yield resulted from sowing soybean in early May when compared mid-April and late May sowing dates. On the other hand, the difference between the oil yield of mid-April sowing date and late May was not much.(1.3).

These results agree with those reported by Galal et al.(1979) and Bonari et al.(1987).

B)- Effect of irrigation regimes:-

The data listed in Table(16), show the effect of the irrigation regime treatments on the average values of the oil yield of soybean(combined average of three seasons).

The results in Table(16), reveal that irrigation regime treatments had a significant effect on the oil yield of soybean.

The highest average value of oil yield of soybean was 542.8 kg./faddan, obtained from irrigation at 1.4 accumulative pan evaporation(short irrigation intervals). However, the lowest one was 323.2 kg./faddan, resulted from irrigating soybean at 0.6 accumulative pan records (long irrigation intervals).

The oil yield of soybean significantly decreased by 7.6 , 16.8 , 23.8 and 40.5 % when water stress increased from irrigation at 1.4 to irrigation at 1.2 , 1.0 , 0.8 and 0.6 accumulative pan evaporation, respectively.

It can be concluded that the oil yield of soybean seeds in kg./faddan increased by irrigation at higher levels of available soil moisture(irrigation at 1.4 acumulative pan evaporation).

These results may be due to the high seed yield and maximum oil percentage, resulted from irrigation at short intervals(irrigation at 1.4 or 1.2 accumulative pan evaporation tratments).

These results are in full agreement with those found by Sherif(1978) ; El-Wakeel(1979) and Ali(1981).

C)- Effect of the interaction(A x B):-

The effect of the interaction between sowing dates and irrigation regime treatments on the average values of the oil yield of soybean seeds(kg./faddan) is presented in Table(17).

The data recrded in Table(17), show that the average values of oil yield of soybean seeds(cmbined over three seasons) significantly affected by the interaction between sowing dates and irrigation regime treatments.

The highest average value of oil yield of soybean seeds was 618.0 kg./faddan, resulted from sowing soybean in early May and irrigation at 1.4 accumulative pan evaporation(D_2 x I_5 tratment).

The lowest average value of oil yield of soybean seeds was 240.9 kg./faddan, obtained when soybean was planted in late May and irrigated at 0.6 accumulative pan evaporation(D_3 x I_1 treatment).

It can be reveal that the oil yield of soybean seeds increased by sowing soybean in early May **time** and irrigation at 1.4 accumulative pan evaporation or at short intervals.

These results may be due to the high seed yield of soybean resulted from sowing in early May and irrigation in short intervals(irrigation at 1.4 accumulative pan evaporation) as well as the high oil percentage in seeds obtained from frequent irrigation(I_5 treatment).

3- Protein percentage in deeds

The average values(combined of three seasons) of the crude protein percentage in soybean seeds as affected by sowing dates and irrigation regime treatments are listed in Table(16).

A)- Effect of sowing dates:-

The effect of soybean sowing dates on the average values of the crude protein percentage in soybean seeds is presented in Table(16).

The results in Table(16), prove that the average values of the crude protein percentage in soybean seeds significantly affected by sowing dates(in the combined analysis of the three seasons).

The highest average value of the crude protein percentage in soybean seeds was 34.1 %, obtained from sowing soybean in the late May sowing date. Whereas, the lowest average value was 32.1 %, resulted from sowing soybean in mid-April.

The crude protein percentage in seeds significantly increased by 5.9 and 2.9 % when sowing date delayed to the late May sowing date, as compared with mid-April and early May sowing dates , respectively.

It can be concluded that the crude protein percentage in soybean seeds increased when sowing date delayed after mid-April time.

These results may be due to the effect of the night temperature on protein percentage as well as the negative relation between the oil and protein contents of seeds under sowing dates.

In this respect, Saito(1961), reported that high night temperature increased the protein content of soybean seed, therefore, the protein content of seeds increased in the late sowing dates. Galal et al.(1979), pointed out that the reduction in day temperature during the pod-filling stage may be the reason in increasing the crude protein content in the late plantings. They added, that the correlation coefficient between mean temperatures and protein contents were found to be - 0.47.

These results are consistent with those reported by Essmail(1978) ; Galal et al.(1979) and Eweida et al.(1986).

B)- Effect of irrigation regimes:-

The average values of the crude protein percentage of soybean seeds as affected by irrigation regime treatments are listed in Table(16).

The results presented in Table(16), reveal that crude protein percentage in soybean seeds significantly affected by irrigation regime treatments.

The highest value of crude protein percentage in seeds was 34.8 %, obtained by irrigation at 0.6 accumulative pan evaporation(prologed irrigation intervals).Whereas, the lowest one was 31.5 %, resulted from irrigation at 1.4 accumulative pan evaporation.

The crude protein percentage in seeds significantly decreased by 2.3 , 4.6 , 7.8 and 9.5 % when irrigation applied at 0.8 , 1.0 , 1.2 and 1.4 accumulative records of pan evaporation, respectively, in comparison with 0.6 accumulative pan evaporation records.

It can be concluded that the crude protein percentage in soybean seeds increased as water stress increased,i.e. irrigation at 0.6 accumulative pan evaporation records.

These results may be due to the water stress effects in reducing the carbohydrates accumulation and consequently the protein content increased.

In this connection, Sherif(1983),indicated that water stress until small amounts of available water remined in soil increased the protein content in soybean seeds.

These results are in full agreement with those found by Sherif(1978) ; Ali(1981) and Sherif(1983).

C)- Effect of the interaction(A x B):-

The results presented in Table(16), reveal that the interaction between sowing dates and irrigation regimes had no significant effect on the crude protein percentage in soybean seeds(in the combined analysis of three years).

4- Crude protein yield

The average values(combined over seasons)of the crude protein yield of soybean seeds in kg./faddan as affected by sowing dates and irrigation regimes **are presented in** Table(16).

A)- Effect of sowing dates:-

The combined average values listed in Table(16),show that the crude protein yield of soybean **significantly** affected by the different sowing date treatments.

The crude protein yield of soybean significantly decreased by 1.9 and 27.6 % when soybean was planted three weeks before or after the early May sowing date.

The highest average value of crude protein yield of soybean seeds was 687.1 kg./faddan, resulted from sowing spoybean in early May.

The lowest average value of crude protein yield of soybean seeds was 497.6 kg./faddan, obtained from sowing soybean in **late** May time.

It can be concluded that the crude protein yield of soybean seeds increased when soybean was planted in early May sowing date.

These results may be attributed to the hign seed yield, obtained from sowing soybean in early May, as well as the high protein percentage in seeds resulted in this sowing date when compared with the late May sowing date.

These results are in good agreement with that found by Bonari et al.(1987).

B)- Effect of irrigation regimes:-

Regarding to the effect of irrigation regimes on the crude protein yield of soybean seeds, the data presented in Table(16), clearly show that irrigation regimes has a significant effect on the crude protein yield in kg. / faddan(in the combined analysis of the three seasons).

The highest average value of crude protein yield of soybean seeds was 664.9 kg./faddan, resulted from I_5 treatment(irrigation at 1.4 accumulative pan evaporation).

The lowest average value of crude protein yield of soybean seeds was 497.3 kg./faddan, obtained from I_1 treatment(irrigation at 0.6 accumulative pan evaporation).

The crude protein yield of soybean seeds significantly decreased by 2.9 , 6.6 , 14.9 and 25.2 % when water stress increased from 1.4 to 1.2 , 1.0 , 0.8 and 0.6 accumulative pan evaporation treatments, respectively.

It can be reveal that irrigation at 1.4 accumulative pan evaporation(short irrigation intervals) increased the crude protein yield of soybean seeds.

These results may be due to the increase in soybean seed yield /faddan , resulted from the frequent irrigation in short intervals.

These results are in full agreement with those found by Ali(1981) and Sherif(1983).

C)- effect of the interaction(A x B):-

The data presented in Table(16), show that the average values of the crude protein yield of soybean seeds were not significantly affected by sowing dates and irrigation regime treatments in the combined analysis of the three seasons(1986 to 1988).

Table (16): The average values of some chemical properties in soybean seeds as affected by sowing date and irrigation regime treatments. (combined average of three seasons).

Treatments	Chemical properties of seeds			
	Oil percentage %	Oil yield kg./ faddan	Protein percentage %	Protein yield kg./ faddan
Sowing dates:				
Early (D_1)	25.3	490.6	32.1	612.3
Moderate (D_2)	24.0	503.5	33.1	687.1
Late (D_3)	22.3	330.7	34.1	497.6
Mean	23.9	441.6	33.1	599.0
L. S. D. :				
Sowing dates 5%	0.24	9.45	0.16	14.2
Sowing dates 1%	0.33	12.95	0.22	19.4
Irrigation regimes:				
0.6 pan (I_1)	22.4	323.2	34.8	497.3
0.8 pan (I_2)	23.0	389.0	34.0	565.8
1.0 pan (I_3)	23.8	451.5	33.2	621.3
1.2 pan (I_4)	24.7	501.4	32.1	645.5
1.4 pan (I_5)	25.4	542.8	31.5	664.9
Mean	23.9	441.6	33.1	599.0
L. S. D. :				
Irrigation regimes 5%	0.29	10.8	0.24	16.7
Irrigation regimes 1%	0.39	14.2	0.32	22.0
D x I 5%	N.S.	18.7	N.S.	N.S.
D x I 1%	N.S.	24.6	N.S.	N.S.

Table (17): The average values of oil yield in kg./faddan of soybean as affected by the interaction between sowing dates and irrigation regime treatments.
(combined of 1986 to 1988).

	Oil yield in kg./faddan					
	Irrigation regimes					
	I_1	I_2	I_3	I_4	I_5	Mean
Early (D_1)	358.0	435.2	507.8	556.0	595.8	490.6
Moderate (D_2)	370.8	444.3	514.5	569.9	618.0	503.5
Late (D_3)	240.9	287.4	332.3	378.2	414.7	330.7
Mean	323.2	389.0	451.5	501.4	542.8	441.6
L. S. D. :						
Interaction 5%						18.7
D x I 1%						24.6

V. Crop Water Use

Water consumptive use,often called evapotranspiration refered to water used by plants in transpiration and growth and that evaporated from adjacent soil and precipitation intercepted by plant foliage. It is expressed as a water depth in cm. or inches .

1- Actual evapotranspiration(ET.):-

i)- Seasonal evapotranspiration(ET.):-

Seasonal evapotranspiration by soybean as a function of sowing dates and irrigation regime treatments in 1986, 1987 and 1988 seasons are presented in Table(18) .

The average values of seasonal ET.,irrespective to soybean sowing dates and irrigation regime treatments were 60.8 , 63.4 and 68.7 cm., in 1986 ,1987 and 1988 seasons, respectively .

These results show that evapotranspiration of soybean was higher in 1988 season when compared with those in 1986 and 1987 seasons .

Such pattern of finding can be attributed to the differences in climatic factors which affected greatly the ET., rates of soybean crop (Tables: 5, 6 and 7) .

These results are in good agreement with that reported by Pruitt(1960), who pointed out that water consumptive use was closely correlated with climatic conditions . Also, Chang(1971), concluded that evapotranspiration by plants depends on the evaporative power of the air as determined by temperature , relative humidity and net radiation .

The same results were found by Sherif(1983) ; Doorenbos et al.(1986) and Abbas(1988) .

A)- Effect of sowing dates:-

Regarding to the effect of sowing dates on seasonal evapotranspiration by soybean, the data presented in Table (18), reveal that the seasonal ET., was affected by sowing dates in the three seasons i.e. 1986 , 1987 and 1988 .

The maximum average values of seasonal ET., were 66.3 , 68.1 and 75.1 cm., in 1986, 1987 and 1988 seasons, respectively, obtained from sowing soybean in mid-April (D_1 treatment) .

The minimum ET., values were 55.0, 58.5 and 62.9 cm., obtained from sowing soybean in late May(D_3 treatment) in 1986 , 1987 and 1988 seasons , respectively .

Sowing soybean in early May(D_2 treatment) resulted in decreasing seasonal ET., by 7.7 , 6.8 and 9.2 % in 1986, 1987 and 1988 seasons, respectively, when compared with mid-April sowing date. However, it increased than those of late May sowing date by 10.2 , 7.9 and 7.8 % in 1986,1987 and 1988 seasons , respectively .

It can be reveal that sowing soybean in mid-April caused an increase in the seasonal evapotranspiration , whereas delaying sowing date than mid-April resulted in decreasing it .

These results emphasize that sowing date affected seasonal evapotranspiration of soybean crop .

These results may be due to the differences in the values of climatic factors during the growing season, the length of the growing season which increased by sowing soybean in mid-April when compared with the other two sowing dates and the length of maximum water demands period(mid-season period) which increased in the mid-April sowing date than the two other sowing dates .

All these reasons mentioned above caused the higher values of seasonal ET., resulted from sowing soybean in mid-April(D_1 treatment) when compared with D_2 and D_3 sowing date treatments .

In this connection, Jensen(1968), concluded that the crops such as small grains would not necessarily require the same amount of water when they are grown in widely different climatic conditions or at different times during the year in the same location .

Thus, evapotranspiration of a crop cannot be discussed without considering the crop season and potential ET., at various stages of plant growth .

These results are in agree with those found by Yousef (1985) ; Doorenbos et al.(1986) and Gab-Alla et al.(1986).

B)- Effect of irrigation regimes:-

The effect of irrigation regime treatments in 1986 , 1987 and 1988 seasons are presented in Table(18) .

The results presented in Table(18), show that the higher values of seasonal evapotranspiration were 72.0 , 76.4 and 81.3 cm., resulted from irrigating soybean at 1.4 accumulative pan evaporation records in 1986 ,1987 and 1988 seasons , respectively .

The lower values were 51.0 , 54.0 and 56.4 cm., obtained from irrigating soybean at 0.6 accumulative pan evaporation records in 1986 , 1987 and 1988 seasons , respectively .

The results presented in Table(18), reveal that increasing water stress from I_5 treatment to I_4 , I_3, I_2 and I_1 treatments resulted in decreasing seasonal ET., of soybean by 9.0 , 17.2 , 22.2 and 29.2 %, respectively, in 1986 season . Corresponding the reduction percentages in 1987 season were 11.0 , 19.5 , 25.4 and 29.3%, respectively.

In 1988 season, the respective values were 16.9 , 17.3,22.6 and 30.6 %, respectively.

The results listed in Table(18),show that the seasoal ET., of soybean(average of three seasons) increased by 8.2, 14.3 , 22.8 and 29.7 % when irrigation intervals decreased from I_1 treatment to I_2 ,I_3 , I_4 and I_5 irrigation regime treatments , respectively .

These results show that when the pan evaporation rate increased the seasonal ET., of soybean increased .

These results indicate that seasonal ET., of soybean crop leads to the higher values by frequent irrigation in short intervals, whereas the lower values of seasonal ET., were resulted from the prolonged irrigation intervals .

It is clear that seasonal evapotranspiration of soybean crop increased as the available soil moisture increased in the root zone by frequent irrigation in short intervals(irrigation at 1.4 accumulative pan evaporation).

In this respect, Tanner <u>et</u> <u>al</u>.(1960),indicated that total ET.,depends on available water to plants,available water of the soil surface and net radiation. Wiegand(1962), pointed out that the drying rate of a bare soil is more proportional to the water content and inversely proportional to time and a drying front advances into the soil linearly . Doorenbos and Pruitt(1977), stated that after irrigation or rain,the soil water content will be reduced primarly by evapotranspiration. As the soil dries the rate of water transmitted through the soil will be reduced. The effect of soil water content on evapotranspiration varies with crop and soil type as well as water holding characteristics.

These results are in full agreement with those found by Doss and Thurlow(1974) ; Mayaki et al.(1976) ; Sherif (1978) ; El-Wakeel(1979) ; Reicosky and Deaton(1979) ; Ibrahim(1981) ; Sherif(1983); Yousef(1985) and Abbas(1988).

ii)- Daily ET.,rate:-

The daily evapotranspiration rates by soybean plant as affected by sowing dates and irrigation regims during 1986 , 1987 and 1988 seasons are presented in Tables(19 and 20)

As ageneral trend, the results show that the daily rates were low through the initial growth period.

These results can be ascribed to that the vegetation was not established yet and most of the water loss is by evaporation. Thereafter, the daily values of water use increased gradually during the crop development stage.

These is mainly due to the increase in the plants cover.

The maximum value of daily rates were recorded at mid-season stage when the plants aged 56 - 105 days from sowing. Then the daily rate of water use redecreased again at the late season stage as the plants stated maturity . At the harvesting time, daily rates of crop ET., were at a minimum value owing to the crop maturation .

This trend was found to be true either in the three seasons or/and under the various treatments of sowing dates or irrigation regimes .

These results are in full agreement with those reported by Sherif(1983) and Abbas(1988) .

In this respect, Lemon _et al_.(1959), reported that the gradual increase in evapotranspiration from planting to maturity can be explained on the basis of percent cover . The decrease in ET., after maturation is probably resulted from the plant development factor. However, in most studies soil water is not maintained at a high level after maturity. Fretschen and Van Bavel(1964), found that when plants reached maturity, evapotranspiration was much less than at earlier stages of growth .

A)- Effect of sowing dates:-

Regarding to the effect of sowing dates on the daily rates of evapotranspiration, the data illustrated in Table (19), reveal that the values were somewhat lower in the mid-April sowing date than those, obtained from the early and late May sowing dates in 1986 season. This trend was found to be true in all soybean growth stages.

The variation in daily ET.,rates between the early May and late May sowing dates was not clear enough . In 1987 and 1988 seasons the higher values of daily ET., rates during the initial and crop development stages were resulted from sowing soybean in early May(D_2 treatment), followed by the late May sowing date(D_3 treatment).

The lower values of daily Et rates during the initial and crop development stages in 1987 and 1988 seasons were resulted from sowing soybean in mid-April sowing date.

The data presented in Table(19), show that the higher values of daily ET.,rate in 1987 and 1988 seasons during mid-season , late season and harvesting stages were resulted from the mid-April sowing date, followed by early May sowing date .

These results may be due to the differences in climtic factors through the growth periods of different sowing dates, as well as the length the growing season period of mid-April sowing date.

In other words, the higher values of daily ET., rates of mid-April sowing date during mid-season ,late season and harvesting stages may be due to the high temperature and radiation values occured during these three stages i.e. from mid-June to the end of August(Tables: 5,6 and 7).

However,the initial and crop development stages of mid-April sowing date occured during mid-spring where the values of air temperature and solar radiation are still low. Whereas, in early and late May sowing dates the two stages occured during the high temperature and radiation values of summer.

In this connection, Doorenbos **et al.**(1979), reprted that the soybean growing season can be divided to five development stages as follows:

1- Initial period : 20 - 25 days from sowing.
2- Development stage: 25 - 35 days.
3- Mid-season stage: 45 - 65 days.
4- Late-season stage: 20 - 30 days.
5- Harvesting stage: after late season stage till harvesting time.

B)- Effect of irrigation regimes:-

The average values of daily ET., rates as affected by irrigation regime treatments are listed in Table(20).

The results presented in Table(20) , indicate that prolonged irrigation intervals(irrigation at I_1 treatment) resulted in decreasing the daily ET.,rates of soybean at all growth stages.

Shortining the period between irrigations resulted in increasing the daily ET., values during the five growth stages of soybean plant.

These results were found to be similar during the three seasons under study.

The daily evapotranspiration rate increased by 0.14 cm., 0.17 cm., and 0.15 cm., when irrigation intervals decreased from I_1 treatment to I_5 treatment in 1986,1987 and 1988 seasons , respectively.

It can be concluded that increasing the available soil moisture in the root zone of soybean plants caused an increase in the daily evapotranspiration rates.

The explanation of such results was reported by Black(1965), who concluded that the independance of the evapotranspiration and density of vegetation canopy may be exists for different reasons when the soil is dry than when water availability for evaporation and transpiration is unlimited. In moist soil the atmosphere is the control but for dry soil the control is in the soil. He added, that under medium conditions the control may be partly in the soil and partly in the plant.

These results are consistent with those reported by Hulpoi _et al_.(1970) ; Doss and Thurlow(1974); Singh and Whiston(1976) ; El-Wakeel(1979) ; Ibrahim(1981);Reicosky _et al_.(1982) and Abbas(1988).

Table (18): The average values of seasonal evapotranspiration of soybean as affected by sowing dates and irrigation regimes in 1986, 1987 and 1988 seasons.

Sowing date treatments	Seasonal ET cm./season					
	Irrigation regimes					Mean
	I_1	I_2	I_3	I_4	I_5	
			1986			
Early (D_1)	54.5	60.9	64.2	71.7	80.2	66.3
Moderate (D_2)	51.5	56.0	60.7	65.8	71.9	61.2
Late (D_3)	47.0	51.0	54.0	59.0	63.8	55.0
Mean	51.0	56.0	59.6	65.5	72.0	60.8
			1987			
Early (D_1)	57.8	61.6	65.8	72.7	82.6	68.1
Moderate (D_2)	54.2	57.4	61.9	68.1	76.1	63.5
Late (D_3)	49.9	52.1	56.8	63.2	70.4	58.5
Mean	54.0	57.0	61.5	68.0	76.4	63.4
			1988			
Early (D_1)	59.9	67.9	74.0	83.9	89.6	75.1
Moderate (D_2)	56.4	62.2	66.4	75.6	80.3	68.2
Late (D_3)	53.0	58.5	61.4	67.5	74.1	62.9
Mean	56.4	62.9	67.3	75.7	81.3	68.7
			Average (1986 to 1988)			
Early (D_1)	57.4	63.5	68.0	76.1	84.1	69.8
Moderate (D_2)	54.0	58.5	63.0	69.8	76.1	64.3
Late (D_3)	50.0	53.9	57.4	63.2	69.4	58.8
Over all mean	53.8	58.6	62.8	69.7	76.5	64.3

Table (19): The average values of daily evapotranspiration in mm./day as affected by soybean sowing dates in 1986 , 1987 and 1988 seasons.

Growth stages / sowing dates		Initial period (days)	Crop development stage (days)	Mid-season stage (days)	Late-season stage (days)	Harvesting stage (days)	Mean
1986							
		21	28-35	35-49	21-28	11-12	117-144
Early	(D_1)	4.0	4.7	5.6	3.7	3.2	4.2
Moderate	(D_2)	4.1	4.9	5.7	4.1	3.3	4.4
Late	(D_3)	4.8	4.7	5.7	4.1	3.3	4.5
Mean		4.3	4.8	5.6	4.0	3.3	4.4
1987							
		21	28	35-42	21-28	9-15	120-128
Early	(D_1)	3.9	4.7	6.6	5.6	4.1	5.0
Moderate	(D_2)	4.6	5.6	6.2	4.2	2.7	4.7
Late	(D_3)	4.3	5.4	5.7	4.3	3.5	4.6
Mean		4.3	5.2	6.2	4.7	3.4	4.8
1988							
		21	28	35-49	21-28	13-15	118-141
Early	(D_1)	4.1	5.1	6.9	4.7	3.6	4.9
Moderate	(D_2)	5.7	5.9	6.2	3.7	2.7	4.9
Late	(D_3)	5.2	6.1	6.0	4.4	3.5	5.0
Mean		5.0	5.7	6.4	4.3	3.3	4.9
Over all average		4.5	5.2	5.9	4.3	3.4	4.7

Table (20): The average values of daily evapotranspiration of soybean in mm./day as affected by irrigation regimes in 1986, 1987 and 1988 seasons.

Irrigation regime treatments \ Growth stages	Initial period (days)	Crop development stage (days)	Mid-season stage (days)	Late-season stage (days)	Harvesting stage (days)	Mean (days)
			1986			
	21	28-35	35-49	21-28	11-12	117-144
I_1 (0.6)	3.9	4.1	4.4	3.5	2.7	3.7
I_2 (0.8)	4.4	4.4	5.1	3.5	2.9	4.1
I_3 (1.0)	4.4	4.7	5.6	3.7	3.0	4.3
I_4 (1.2)	4.4	5.3	6.2	4.1	3.4	4.7
I_5 (1.4)	4.4	5.5	6.7	5.0	4.1	5.1
Mean	4.3	4.8	5.6	4.0	3.2	4.4
			1987			
	21	28	35-42	21-28	9-15	120-128
I_1 (0.6)	4.1	4.5	5.0	3.9	3.1	4.1
I_2 (0.8)	4.2	4.7	5.4	4.1	3.1	4.3
I_3 (1.0)	4.3	5.1	6.0	4.5	3.3	4.8
I_4 (1.2)	4.4	5.8	6.9	4.6	3.4	5.0
I_5 (1.4)	4.5	6.1	7.5	6.5	4.2	5.8
Mean	4.3	5.2	6.2	4.7	3.7	4.8
			1988			
	21	28	35-49	21-28	13-15	118-141
I_1 (0.6)	4.7	4.5	4.8	3.7	3.1	4.2
I_2 (0.8)	4.8	5.1	5.6	3.8	3.1	4.5
I_3 (1.0)	5.0	5.6	6.2	4.4	3.3	4.9
I_4 (1.2)	5.1	6.3	7.3	5.0	3.5	5.4
I_5 (1.4)	5.4	7.1	8.0	4.6	3.5	5.7
Mean	5.0	5.7	6.4	4.3	3.3	4.9
Over all average	4.5	5.2	5.9	4.3	3.4	4.7

2- The Class A pan evaporation studies:-

i)- Pan evaporation and some climatic factors relation:-

Correlation between the daily Class A pan records and some climatic factors i.e. mean air temperature ,mean wind speed , mean relative humidity and mean solar radiation has been estimated. The data of the three seasons(1986 to 1988) were subjected to statistical analysis. The rsults of the correlation coefficient and linear regression parameters are presented in Table(21).

The data recorded in Table(21), show that the relation between the daily mean of air temperature and daily Class A pan evaporation was significant in two seasons out of three. Thses relation was not significant in 1986 season.

This trend is expected since the water loss from any free water surface depends primarly on the evaporative power of the air. The air temperature affected greatly the evaporation rate.

The regression line of the Class A pan evaporation and the daily mean of air temperature relationship is as fllows:-

$$Y = 0.2098 X + 2.0106$$

where:

Y = The Class A pan evaporation rate in mm./day

X = Mean air temperature in $^{\circ}C$.

In this respect , King(1956) , revealed that the accuracy increased gradually with increasing the period.

Regarding to the relation between mean daily wind speed and the Class A pan evaporation rate the data listed in Table(21), reveal that the relationship between the two variables was not significant in the three seasons of this study.

Such pattern of finding can be ascribed to the slight variations in mean daily wind speed during the period of the study when compared with the Class A pan evaporation rates.

These results are in good agreement with those found by Chang(1971), who stated that evaporation is a diffusive process, partly turblent and partly molecular. The turblent process is the domen in the thin layer near the surface of evaporation. The upward flow of water vapour is more affected by the changes in the vertical gradient of vapour pressure and mixing rate.

Table(21), represent the relationship between mean daily relative humidity measurements and the Class A pan evaporation rates.

The correlation analysis showed a negative relation between the two variables.

The statistical analysis revealed that the correlation values were highly significant in the three seasons. The correlation coefficient values between the two variables were - 0.6022 , - 0.1624 and 0.6331 in 1986 , 1987 and 1988 seasons , respectively.

These results may be due to the fact that diffusion of vapour from a free water surface depend on the amount of water vapour in the air.

The linear function of the relationship between mean daily relative humidity and daily Class A pan evaporation is as follows:-

$$Y = - 0.0952 X + 12.8674$$

where:

Y = Class A pan evaporation rate in mm./day.

X = Mean daily relative humidity %.

The correlation coefficient values between meam daily solar radiation(expressed in equivalent mm./day) and the Class A pan evaporation rates are presented in Table(21).

The statistical analysis showed that the correlation coefficients between the two variables were significant in the three seasons i.e. 1986, 1987 and 1988.

The correlation coefficient values were 0.4713,0.5800 and 0.7420 in 1986 , 1987 and 1988 seasons, respectively.

These results may emphasize that the evaporation rate from the free water surface is more related to the amount of solar radiation.

Some emperical formulae used for estimating potential evapotranspiration depends mainly on solar radiation, such as Jensen and Haise formula.

In this connectio', Makkink(1957), pointed out that the higher the temperature the greater the proportion of solar radiation energy used in evapotranspiration. Whereas, Chang(1971), concluded that in the absence of advected energy a close relationship between potential ET., and net radiation usually exists.

The results presented in Table(21), described the linear function that predict the rate of water loss from the Class A pan in relation to mean daily solar radiation as follows:-

$$Y = 0.8617 X + 1.4325$$

where:

Y = The Class A pan evaporation rate in mm./day.

X = Mean daily solar radiation in mm./day.

These results conclude that the Class A pan rates were highly correlated with some climatic factors. The same climatic factors are the principle factors affected the evapotranspiration of plants. Therefore, using the Class A pan in estimating the short term fluctuations of ET., may be more accurate.

In this connection, Mukammal and Bruce(1960), derived some regression equations showing the relative importance of solar radiation, relative humidity and wind speed for the Class A pan evaporation and found that it were in the rates of 80 :6:14, respectively. Robins and Haise(1961), remarked that evaporimeters reflects the local and short term of climatic variations and it may be the simlest and most successful methods for use in the presence of the advected energy. Stanhill(1961), compared the potential evapotranspiration estimated by eight methods irrispective to its accuracy , costs and time. He concluded that the Class A pan evaporation method is inexpensive , easy to handle and the most satisfactory method for the field use. Smith(1964), reported that the Class A pan provided better estimation of monthly and seasonal power of the air than other formulae. Doorenbos and Pruitt(1975),found that evaporation from the pan may provide a measurement of integrated effect of radiation, wind speed,temperature and relative humidity on evaporation from an open water surface, and in a similar fashion the plant response to the same climatic variables.

Table (21): The correlation coefficient(r) and linear regression parameters(Y = a + b X) for relationships between the Class A Pan evaporation in mm./day and daily means of some climatic factors(X) in 1986 , 1987 and 1988 seasons.

Climatic factors (X)	Parameters	Seasons		
		1986	1987	1988
Mean daily air temperture °C	r	0.2827	0.6150**	0.4788*
	b	0.0881	0.2149	0.2660
	a	4.6404	2.1255	0.7938
Mean daily wind speed m./Sec.	r	0.2330	-0.0699	-0.0168
	b	0.4421	-0.1573	-0.0486
	a	5.8361	8.1901	8.4344
Mean daily relative humidity%	r	-0.6022**	-0.1624	-0.6331**
	b	-0.0857	-0.0301	-0.1103
	a	11.8073	9.4235	14.1058
Mean daily solar radiation mm./day	r	0.4713*	0.5800**	0.7420**
	b	0.4458	0.7937	1.4045
	a	2.2964	-0.5928	-6.6811

Where:

* = Significant on the level of 5 % .

** = Significant on the level of 1 % .

ii)- Class A pan evaporation and soybean ET.,relation:-

Interist in using Class A pan evaporation as direct measurements of potential evapotranspiration or scheduling crop irrigation has been increased recently.

The simlist method to evaluate the accuracy of the Class A pan in scheduling crop irrigation is to find out the relation between pan evaporation rate and the crop evapotranspiration rates.

Table(22), represents the correlation between actual evapotranspiration measured from the field of soybean on the basis of the wet treatment,i.e. irrigation at 1.4 of accumulative pan evaporation and daily records of the pan evaporation. These relationship was extended in the three sowing dates of soybean(D_1 , D_2 and D_3 treatments) in 1986 , 1987 and 1988 seasons.

The results presented in Table(22), reveal a close relationship between actual ET., of soybean and the daily Class A pan evaporation records in 1987 and 1988 seasons for D_1 , D_2 and D_3 sowing date treatments.

The statistical analysis of the data showed that these relationships were significant in 1987 and 1988 seasons for D_1 , D_2 and D_3 sowing date treatments.However, in 1986 season the relation between actual ET., and the Class A pan evaporation records was significant only at mid- April sowing date(D_1 treatment).

These results may be concluded that the crop ET., of soybean is closely correlated with the daily rates of the Class A pan evaporation.

In this connection, Brutsaert(1965), reported that the correlation coefficient between evapotranspiration measured by lisimeters and results obtained by the Class A pan was 0.977. Chang(1971), pointed out that the Class A pan evaporation can be used for estimating the ET., throughout the crop life cycle.

The correlation studies mentioned above proved that the relationships between the Class A pan evaporation and some climatic factors as well as the evapotranspiration by the crop were close and significant during the three seasons of this study.

The Class A pan is inexpensive , easly to handle in the field , needs short time and little efforts for its records calculations , can be located in the experimental area, avoiding the soil destruction by sampling of normal method , save efforts of transporting and weighing the soil samples and will incorporate most of the climatic factors affecting evaporation from the water surface as well as factors affecting crop evapotranspiration.

Therefore, it can be concluded that the Class A pan evaporation records can be used as a direct method for scheduling the crop irrigation and measuring the ET., of the crop when it is well located and all factors are considered.

These results are in good agreement with those found by Hagood(1964) ; Bowman and King(1965) ; Brutsaert(1965); Chang(1971) ; Ibrahim(1981) and Eid and Metwally(1982).

Table (22): The correlation coefficient values(r) for the relation between the Class A pan evaporation in mm. /day and soybean evapotranspiration rates in mm. / day derived from the wet irrigation treatment(I_5) under the soybean sowing date treatments in 1986, 1987 and 1988 seasons.

Sowing date treatments		Correlation coefficient values(r)		
		Seasons		
		1986	1987	1988
Early	(D_1)	0.5746**	0.7342**	0.7251**
Moderate	(D_2)	0.3953	0.7199**	0.8653**
Late	(D_3)	0.4039	0.5421*	0.5827*

Where:

* = Significant on the level of 5 %.

** = Significant on the level of 1 %.

3- Potential evapotranspiration(ET_p):-

Penman(1956),defined the potential evapotranspiration as the amount of water transpired per time unit by a short green crop , completely shading the ground and of a uniform height. The ET_p is determined primarly by the weather and is not affected by plant species.

The study was extended to compare the ET_p estimated by five methods namely, modified Penman,Jensen and Haise, Class A pan evaporation, Turc and Blaney and Criddle with measured evapotranspiration values of soybean.

i)- Weekly ET_p:-

The weekly values of potential evapotranspiration , based on the weekly agrometeorological data during 1986, 1987 and 1988 seasons are listed in Tables(23,24 and25).

The results presented in Tables(23,24 and 25),show that the weekly ET_p values started with low rates through April and increased gradually to reach it's maximum value during June and July, then redecreased again till the end of the season. These results were found to be true for the five methods used in this study during 1986 ,1987 and 1988 seasons.

This trend may be due to the increase in temperature and solar radiation during June and July period as shown in Tables(5 , 6 and 7).

In this connection, Chang(1971), concluded that the rate of ET_p depends on the evaporative power of the air, determined by temperature, winds, humidity and radiation.

ii)- Seasonal ET_p :-

Concerning to the seasonal ET_p values estimated by the five methods, the results presented in Table(26) , reveal that the ET_p values, calculated by Turc method were 93.9 , 97.3 and 97.3 cm., in 1986 , 1987 and 1988 seasons, respectively. However, the ET_p values, estimated by Blaney and Criddle method were 98.4 , 98.7 and 98.4 cm., in 1986 , 1987 and 1988 seasons, respectively.

These results show that the ET_p values estimated by either Turc method or Blaney and Criddle method were underestimating the average values of ET_p for all methods (111.4 , 115.3 and 120.6 cm., in 1986 , 1987 and 1988 seasons , respectively).

The lower values, obtained by Blaney and Criddle method may be due to the few climatic parameters involed in these method, i.e. mean air temperature(^{o}F) and the percentage of day time hours(p) in predicting the ET_p values. These two factors are not enough in reflecting the effect of climate on evapotranspiration.

In this respect, Jakson(1960) and Stanhill(1961) , concluded that the performance of the Blaney and Criddle method is usually very poor. Chang(1971), pointed out that the Blaney and Criddle formula suffers from great drowbacks.

The lower values, obtained by Turc method may be due to the fact that radiation is not enough to get reasonable estimates of potential evapotranspiration, as well as the constant of these formula is not suitable for Giza region.

In this connection, Jensen(1966), pointed out that the constant of any emperical formula used in estimating ET_p values is the major limiting factor in obtaining good estimation and the constant may be not applicable for different climatic regions without calibration. Chang (1971), reported that the emperical formulae can not be expected to have general validity.

These results are in good agreement with that found by Miseha(1983), who revealed that Blaney and Criddle and Turc formulae were inconsistent when calculated in short or long time basis. He added that, the ET_p values estimated by Turc method were lower than those obtained by Penman method, Therefore, he changed the costant of Turc method from 0.013 to 0.017 to be more suitable for Giza region.

The results presented in Table(26), show that the ET_p values estimated by modified Penman method were 131.4 , 131.4 and 141.9 cm., in 1986 , 1987 and 1988 seasons , respectively. Whereas, the ET_p values estimated by Jensen and Haise method were 124.7 , 126.0 and 133.4 cm., in 1986, 1987 and 1988 seasons, respectively.

These results reveal that the ET_p values, estimated by modified Penman or Jensen and Haise formulae were overestimating the average values of the ET_p of the all methods.

The Class A pan evaporation records was used as a direct measurements of estimating ET_p values.

The results presented in Table(26), show that the ET_p values,estimated by the Class A pan evaporation method were 111.4 , 126.0 and 132.1 cm.,in 1986,1987 and 1988 seasons , respectively.

The ET_p values estimated by the Class A pan method were lower than those calculated by either modified Penman or Jensen and Haise methods.

Such reduction was equal to 8.1 % (average of the three seasons). This reduction accured in the Class A pan records may be due to it's screening.

In this connection, Stanhill(1962), found that the screening of the Class A pan reduced it's evaporation by 10.4 %. Doorenbos and Pruitt(1977), suggested a 10.0 % increasing factor for water loss from screened Class A pan.

The results listed in Table(26), reveal that modified Penman and Jensen and Haise values are very clse to each other. These values are more related to the actual ET., when considering that the ET., by the crop is less than the potential evapotranspiration.

In this respect, Jensen(1968), indicated that most of the field crops require less amounts of water than those would be needed to meet the potential evapotranspiration even though adequate soil moisture is provided.

The ET_p values, estimated by the Class A pan method are nearly close to those obtained by modified Penman or Jensen and Haise methods when screening factor has been taken in consideration.

On the other hand, the calculations of modified Penman method is very complecated and needs more climatic factors, whereas, the Class A pan needs to be well located only for providing accurate values of ET_p .

In this connection, Pruitt and Jensen(1955)as well as Suzki and Fukuda(1958), reported that the Class A pan evaporation rate gave much closer estimates of crop water use than emperical formulae. They also, found that the ET, measured by the Class A pan evaporation method was highly correlated ($r = 0.97$).

Stanhill(1961), concluded that calculating the ET_p by Penman's method or by the Class A pan evaporation are the most satisfactory method. Miseha(1983), found a close relationship between the daily ET_p values determined from Penman's method and the Class A pan records with correlation coefficient of + 0.79 for Giza region.

The previous results emphasize that the Class A pan offers a good method and reliable estimates of potential evapotranspiration. Also, the Class A pan is a simplist, inexpensive , easily operated and need no more climatic data.

Therefore, it can be concluded that the Class A pan can be used successfuly in scheduling crop irrigation as well as estimating the potential evapotranspiration of the short-term fluctuations during the crop season.

Table (23): The weekly values of potential evapotranspiration estimated by different methods during soybean growing season at Giza region in 1986 season.

Period (Week)	Potential evapotranspiration in cm./week				
	Modified Penman	Jensen and Haise	Class A Pan	Turc	Blaney and Criddle
16/4 - 22/4	5.11	4.69	4.41	3.57	3.92
23/4 - 29/4	5.95	4.55	5.18	3.64	3.71
30/4 - 6/5	4.96	4.34	4.69	3.64	3.92
7/5 - 13/5	4.97	4.48	4.62	3.64	3.92
14/5 - 20/5	5.36	4.76	4.62	3.85	3.92
21/5 - 27/5	5.77	4.69	5.11	4.06	4.20
28/5 - 3/6	6.51	5.88	5.25	4.34	4.41
4/6 - 10/6	6.94	6.30	7.00	4.83	4.90
11/6 - 17/6	6.52	6.09	4.38	4.41	4.55
18/6 - 24/6	6.43	6.23	4.34	4.34	4.69
25/6 - 1/7	6.48	6.23	5.04	4.41	4.69
2/7 - 8/7	6.64	6.09	5.46	4.34	4.48
9/7 - 15/7	6.08	6.30	5.04	4.41	4.55
16/7 - 22/7	6.13	6.23	5.11	4.27	4.76
23/7 - 29/7	5.69	6.16	5.04	3.99	4.69
30/7 - 5/8	5.61	6.02	4.97	4.27	4.41
6/8 - 12/8	5.49	5.81	4.48	4.13	4.41
13/8 - 19/8	5.15	5.74	4.97	3.99	4.48
20/8 - 26/8	5.58	5.60	4.90	3.99	4.41
27/8 - 2/9	5.41	5.60	4.83	3.92	4.48
3/9 - 9/9	4.40	4.76	4.06	3.46	4.06
10/9 - 16/9	5.25	4.97	4.62	3.64	3.99
17/9 - 21/9	3.02	3.20	2.85	2.30	2.90

Table (24): The weekly values of potential evapotranspiration estimated by different methods during soybean growing season at Giza region in 1987 season.

Period (Week)	Potential evapotranspiration in cm./week				
	Modified Penman	Jensen and Haise	Class A Pan	Turc	Blaney and Criddle
14/4 - 20/4	5.04	3.92	4.13	3.85	3.43
21/4 - 27/4	5.04	3.92	3.92	3.36	3.36
28/4 - 4/5	5.53	4.34	4.62	3.92	3.64
5/5 - 11/5	6.02	5.04	5.46	4.13	4.13
12/5 - 18/5	6.93	5.54	5.60	4.41	4.20
19/5 - 25/5	6.02	5.11	5.46	3.92	4.27
26/5 - 1/6	6.03	5.74	6.30	4.55	4.48
2/6 - 8/6	6.37	5.53	5.53	4.13	4.34
9/6 - 15/6	6.02	6.09	6.37	4.34	4.62
16/6 - 22/6	6.30	6.30	6.58	4.48	4.69
23/6 - 29/6	6.72	6.02	6.86	4.34	4.62
30/6 - 6/7	5.88	6.16	5.67	4.34	4.55
7/7 - 13/7	5.74	5.95	5.74	4.27	4.88
14/7 - 20/7	5.88	6.06	6.30	4.27	4.55
21/7 - 27/7	6.23	6.65	6.37	4.48	4.76
28/7 - 3/8	5.60	6.09	5.67	4.13	4.62
4/8 - 10/8	5.32	5.81	5.74	3.99	4.55
11/8 - 17/8	5.18	5.67	5.25	3.92	4.48
18/8 - 24/8	4.76	5.32	4.69	3.85	4.43
25/8 - 31/8	5.81	6.09	4.76	4.34	4.34
1/9 - 7/9	4.97	5.04	4.83	3.64	4.06
8/9 - 14/9	4.83	4.83	4.55	3.50	4.06
15/9 - 22/9	5.20	5.28	5.76	3.76	4.06

Table (25): The weekly values of potential evapotranspiration estimated by different methods during soybean growing season at Giza region in 1988 season.

Period (Week)	Potential evapotranspiration in cm./week				
	Modified Penman	Jensen and Haise	Class A Pan	Turc	Blaney and Criddle
20/4 - 26/4	5.25	3.92	4.27	3.29	3.85
27/4 - 3/5	6.16	4.97	4.66	3.99	3.71
4/5 - 10/5	6.65	5.18	5.91	4.20	3.92
11/5 - 17/5	7.49	6.16	7.24	4.90	3.92
18/5 - 24/5	6.44	6.02	6.46	4.97	3.92
25/5 - 31/5	6.93	5.88	6.97	4.62	4.20
1/6 - 7/6	6.58	5.88	5.71	4.41	4.41
8/6 - 14/6	6.58	6.44	6.58	4.69	4.90
15/6 - 21/6	6.65	6.51	7.12	4.83	4.55
22/6 - 28/6	7.42	6.37	6.84	4.62	4.69
29/6 - 5/7	6.86	6.79	7.12	4.76	4.69
6/7 - 12/7	6.72	6.65	6.85	4.41	4.48
13/7 - 19/7	6.44	6.37	6.30	4.41	4.55
20/7 - 26/7	6.37	6.58	6.14	4.41	4.76
27/7 - 2/8	6.16	6.44	5.85	4.41	4.69
3/8 - 9/8	5.81	6.16	5.48	4.27	4.41
10/8 - 16/8	6.02	6.09	5.16	4.27	4.41
17/8 - 23/8	5.81	6.02	4.62	4.13	4.48
24/8 - 30/8	5.67	5.81	4.71	4.06	4.41
31/8 - 6/9	4.97	5.18	4.80	3.64	4.48
7/9 - 13/9	5.39	4.50	4.02	3.24	3.48
14/9 - 20/9	5.25	5.11	4.97	3.71	3.99
21/9 - 26/9	4.32	4.32	4.32	3.06	3.54

Table (26): The values of potential evapotranspiration in cm./season for soybean in 1986 , 1987 and 1988 seasons, estimated by five methods.

Methods of estimating ET_p	Seasonal potential evapotranspiration in cm.			
	1986	1987	1988	Mean
Modified Penman	131.4	131.4	141.9	134.9
Jensen and Haise	124.7	126.5	133.4	128.2
Class A pan	111.4	126.0	132.1	123.2
Tuec	91.4	93.9	97.3	94.2
Blaney and Criddle	98.4	98.7	98.4	98.5
Mean	111.4	115.3	120.6	115.8

4- Crop coefficient(K_c):-

The crop coefficient(K_c) reflects the crop characteristics on the evapotranspiration by the crop. It is calculated as the dimension less ratio of the crop ET., and the potential evapotranspiration(ET_p).

The average values of the crop coefficient(average of three seasons) of soybean plants throughout it's life cycle as affected by sowing dates are presented in Table (27).

The K_c values presented in Table(27), were calculated according to the actual evapotranspiration of soybean , derived from the wet treatment(irrigation at 1.4 accumulative pan evaporation) considered as the treatment when water is not limiting factor, and the ET_p values estimated by modified Penman , Jensen and Haise and the Class A pan methods.

The results presented in Table(27), show that the K_c value was low at the initial period as a result of the large diffusive resistance of bare soil after planting . Then, the K_c values increased as the percent of crop cover increased. The crop coefficient reached it's maximum value through the mid-season stage.

The K_c values at mid-season stage were 0.85,0.83 and 0.91(average of the three sowing dates) for the modified Penman , Jênsen and Haise and Class A pan methods , respectively.

The higner values of K_c at mid-season stage may be due to the period considered as the peak period of water consumption by soybean plant. Thereafter, the K_c values redecreased again during the late season stage as the crop started maturity. At harvesting time the K_c values were very low due to the crop maturation.

The data listed in Table(27), show that the average values of soybean seasonal K_c were 0.66 , 0.68 and 0.72 when ET_p estimated by modified Penman, Jensen and Haise and Class A pan methods, respectively(average of all sowing dates and the three seasons of the study).

In this connection, Jensen(1968), concluded that the seasonal evapotranspiration for most field crop will be less than the potential evapotranspiration because the soil may be comletely bare for some time before seedling apperance and the leaf area still limited. However, at begining of plant maturity the transpiration resistance seems to increase. Burch et al.(1978), found that the rate of actual evapotranspiration to ET_p , increased from 0.2 in the early period of the season to about 1.2 at later stages for well watered plants . Doorenbos et al.(1979), reported that the K_c of soybean for total growing period was 0.85.

These results are in full agreement with those found by Ibrahim(1981) , Sherif(1983) and Abbas(1988).

The results presented in Table(27), reveal that the crop coefficient of soybean vary according to sowing dates and the ET_p methods at different stages.

The data listed in Table(27), show that the average values of soybean K_c at all growth stages were different between the three methods of ET_p estimations, i.e. modified Penman , Jensen and Haise and the Class A pan evaporation.

The higher K_c values of soybean crop were obtained from the ET_p values estimated by the Class A pan method. Such seasonal values were 0.74 , 0.70 and 0.73 for mid-April , early May and late May sowing dates, respectively.

Such differences between the values of K_c , obtained from the three methods of estimating ET_p, are expected since the ET_p values of each method are not similar.

The results presented in Table(27), reveal that the average values of soybean K_c(average over seasons and ET_p methods) slightly decreased during the initial and crop development stages when soybean was planted three weeks before or after early May time. Thereafter, the K_c values increased during the following growth stages for D_1 and D_3 sowing date treatment when compared with D_2 sowing date treatment.

It can be reveal that sowing soybean in early May time increased the K_c values during the initial and the crop development stages, whereas , the K_c values decreased at the following stages when compared with mid-April and late May sowing dates.

These results may be due to the crop perfor ance and the high yield of soybean resulted from the early May sowing date treatment when compared with mid-April and late May sowing dates. Also, these results may be due to the variation in growing season length and the different actual Et., values resulted from the different sowing dates.

In this connection, Doornbos and Pruitt(1977), found that factors affecting K_c are mainly, crop characteristics, sowing dates , the rate of crop development, length of growing season and climatic conditions.

These results are in harmony with those obtained by the USDA.,(1964); El-Gibali <u>et</u> <u>al</u>.(1970) ; Shahin(1970) and Miseha(1983).

Table (27): The average values of crop coefficient (K_c) of soybean through different growth stages as affected by soybean sowing dates (averages of the three seasons, 1986 - 1988).

ET_p method	Sowing dates	Initial period (days) 21	Crop development stage (days) 28-35	Mid-season stage (days) 35-49	Late-season stage (days) 21-28	Harvesting stage (days) 9-15	Seasonal (days) 114-148
Modified Penman	Early (D_1)	0.52	0.64	0.85	0.74	0.63	0.68
	Moder. (D_2)	0.60	0.70	0.82	0.63	0.45	0.64
	Late (D_3)	0.55	0.70	0.87	0.67	0.57	0.67
	Mean	0.56	0.68	0.85	0.68	0.55	0.66
Jensen and Haise	Early (D_1)	0.65	0.73	0.86	0.70	0.59	0.71
	Moder. (D_2)	0.72	0.78	0.82	0.60	0.45	0.67
	Late (D_3)	0.59	0.72	0.82	0.65	0.58	0.67
	Mean	0.65	0.74	0.83	0.65	0.54	0.68
Class A Pan	Early (D_1)	0.62	0.69	0.92	0.78	0.67	0.74
	Moder. (D_2)	0.65	0.79	0.88	0.67	0.49	0.70
	Late (D_3)	0.60	0.76	0.93	0.75	0.60	0.73
	Mean	0.62	0.75	0.91	0.73	0.59	0.72
(Average of the three methods)							
	Early (D_1)	0.60	0.69	0.88	0.74	0.63	0.71
	Moder. (D_2)	0.66	0.76	0.84	0.63	0.46	0.67
	Late (D_3)	0.58	0.73	0.87	0.69	0.58	0.69
Over all average		0.61	0.73	0.86	0.69	0.56	0.69

5- Water Use Efficiency (W.U.E.):-

The water use efficiency is expressed as kg.seeds/ m^3, of water consumed. The water use efficiency has been used to evaluate different irrigation regime treatments in producing maximum yield per unit of water consumed by the crop plants.

The average values of water use efficiency by soybean as affected by sowing dates and irrigation regimes in 1986, 1987 and 1988 seasons are presented in Table(28).

A)- Effect of sowing dates:-

The average values of water use efficiency **by soybean** in 1986 season were 0.65 , 0.77 and 0.56 kg. seeds/m^3, of water for D_1 , D_2 and D_3 sowing date treatments, respectively. The corresponding values in 1987 season were 0.59 , 0.69 and 0.50 kg.seeds/m^3, water for sowing dates in the same order. The respective values in 1988 season were 0.72 , 0.85 and 0.71 kg.seeds/m^3, of water consumed.

The results listed in Table(28) , clearly show that the highest value of water use efficiency by soybean was resulted from sowing soybean in early May(D_2 treatment). Whereas, the lowest value of W.U.E., was obtained from sowing soybean in late May sowing date(D_3 treatment).

This trend was found to be true in 1986,1987 and 1988 seasons as well as the average of the three seasons.

These results may be due to the higher productivity of seeds and less water consumption resulted from sowing soybean in early May sowing date when compared with the values, obtained from mid-April sowing date.

It is worthly to mention that the early sowing date treatment(mid-April) produced higher values of W.U.E.,by soybean than those of late May sowing date.

The increase of W.U.E., obtained from sowing soybean in mid-April sowing date may be resulted from the high seed yield of this sowing date. Whereas, sowing soybean in late May sowing date resulted in decreasing significantly the seed yield much more than the decrease occured in the seasonal evapotranspiration value of this sowing date.

It can be concluded that sowing soybean in early May time is more efficient in water consumption than the other two sowing date treatments under study.

In this connection, Pendleton(1965) , revealed that in arid and semi arid regions sowing dates are an extremely important cultural practice in efficient use of water.

These results agree with that found by Gab-All et al. (1986).

B)- Effect of irrigation regimes:-

Regarding to the effect of irrigation regimes on the average values of water use efficincy by soybean,the data presented in Table(28) , show that the irrigation regime treatments, based on accumulative pan evaporation records had a great effect on water use efficiency by soybean in 1986 , 1987 and 1988 seasons.

The average values of water use efficiency(average of the three seasons) were 0.63 , 0.67 , 0.71 , 0.69 and 0.66 kg.seeds/m^3, water for I_1 , I_2 , I_3 , I_4 and I_5 irrigation regime treatments , respectively.

The results presented in Table(28), reveal that the highest value of W.U.E., by soybean resulted from the medium irrigation intervals treatment i.e. irrigation at 1.0 accumulative pan evaporation, Whereas, the prolonged irrigation intervals or frequent irrigation intervals beyond 1.0 accumulative pan evaporation treatment resulted in decreasing the values of water use efficiency.

This trend was found to be true in the three seasons under study.

These results may be due to the increase in the seed yield, resulted from irrigation at I_3 treatment, whereas, the increase in the seasonal ET., obtained at this level of irrigation was less than those obtained from irrigation at I_5 or I_4 treatments.

These results are consistent with that reported by Ritchie(1974), who concluded that some water conservation benefits can be derived from moderate water stress. It is well known that plant roots extract more soil water from greater depth at moderate stress conditions than plants irrigated at wet level. Thus, the stored water in the soil profile can be used with more efficiency.

It can be concluded that from the stand point of the water economy, sowing soybean in early May and irrigation at 1.0 accumulative pan evaporation can be recommended. However, When the crop production is more important than water use efficiency, sowing soybean in early May date and irrigation at 1.4 accumulative pan evaporation may be preferable.

In this connection, Haise and Hagan(1967), pointed out that when water is scacer, irrigation should be scheduled to maximize crop production per unit of water applied. However, when the good land is scacer than water, irrigation sould be scheduled to maximize crop production per unit area planted.

These results are in harmony with those reported by Cassel et al.(1978); Sherif(1978); El-Wakeel(1979); Sherif (1983) ; Gab-Alla et al.(1986) and Abbas(1988).

Table (28): The average values of water use efficiency by soybean as affected by sowing dates and irrigation regimes in 1986, 1987 and 1988 seasons .

Sowing date treatments	Water use efficiency kg. seeds/m^3. water					
	Irrigation regimes					Mean
	I_1	I_2	I_3	I_4	I_5	
			1986			
Early (D_1)	0.64	0.66	0.68	0.65	0.63	0.65
Moderate (D_2)	0.76	0.77	0.79	0.77	0.75	0.77
Late (D_3)	0.50	0.56	0.59	0.57	0.56	0.56
Mean	0.63	0.66	0.69	0.66	0.65	0.66
			1987			
Early (D_1)	0.55	0.58	0.64	0.61	0.57	0.59
Moderate (D_2)	0.66	0.71	0.73	0.70	0.66	0.69
Late (D_3)	0.38	0.44	0.54	0.58	0.54	0.50
Mean	0.53	0.57	0.64	0.63	0.59	0.59
			1988			
Early (D_1)	0.68	0.75	0.76	0.71	0.68	0.72
Moderate (D_2)	0.78	0.84	0.91	0.86	0.85	0.85
Late (D_3)	0.72	0.74	0.74	0.70	0.67	0.71
Mean	0.73	0.78	0.80	0.76	0.73	0.76
			Average (1986 to 1988)			
Early (D_1)	0.62	0.66	0.69	0.66	0.63	0.65
Moderate (D_2)	0.73	0.77	0.81	0.78	0.75	0.77
Late (D_3)	0.53	0.58	0.62	0.62	0.59	0.59
Over all mean	0.63	0.67	0.71	0.69	0.66	0.67