4. RESULTS AND DISCUSSION

PART I

EFFECT OF SOIL MOISTURE STRESS

4.1.1. Potato Growth :

4.1.1.1. Plant height :

Plant height of potato at different periods of its growth in fall and summer plantation through the period of study is presented in Table (5). Results clearly indicate that the height of potato plant in summer plantation was found to be greater than fall period. Such results can be related to climatic conditions i.e. air temperature,solar radiation and day length. Several reports noted that long days, 17-21 hr favoured vegetative growth than short days 10-12 hr. (El-Abed, 1979).

The height of potato plant increased by time from planting up to the last sample. Soil moisture stress exhibits a significant response on plant in the three tested periods of growth. These results are similar in the two seasons as well as in both plantations i.e. fall or summer. It can be mentioned that as soil moisture stress increased plant height significantly decreased.

Table (5): **Effect of soil moisture stress on plant height (cm) of potato at various stages of growth cycle.**

Treatments	Season 1989-1990			Season 1990-1991			Mean of two seasons			Relative increase %		
	Days after planting											
	50	65	80	50	65	80	50	65	80	50	65	80
	Summer plantation											
Farmer practice	46.6	75.6	96.0	34.6	60.3	71.0	40.6	68.0	83.5	49	81	100
0.5 bar	50.6	80.6	103.0	39.3	74.0	74.6	45.0	77.3	88.8	51	87	100
1.0 bar	44.6	76.0	98.0	36.6	61.3	72.6	40.6	68.7	85.3	48	80	100
1.5 bar	39.6	66.0	80.6	28.6	48.3	57.6	34.1	57.2	69.1	49	83	100
50%Modified **Penman**	36.0	56.3	70.3	21.6	47.0	56.0	28.8	51.7	63.2	46	82	100
L.S.D. at 5%	11.4	7.9	12.1	5.7	4.7	9.0	5.5	4.2	6.4			
	Fall plantation											
Farmer practice	26.6	52.6	63.0	30.3	56.6	66.6	28.5	54.5	64.8	44	84	100
0.5 bar	30.8	55.6	69.0	32.6	58.0	69.3	31.7	56.8	69.2	46	82	100
1.0 bar	25.9	48.8	59.5	[illegible].8	55.6	65.0	26.4	52.2	62.3	42	84	100
1.5 bar	21.2	40.3	50.0	22.6	48.0	59.6	21.9	44.2	54.8	40	81	100
50%Modified Penman	21.7	42.0	48.8	22.3	43.3	55.0	22.0	42.7	51.9	42	82	100
L.S.D. at 5%	2.9	3.1	6.7	4.2	6.9	11.2	2.3	3.0	5.6			

Maximum values of plant height were gained from treatment irrigated at 0.5 bar followed by those plots irrigated at 1.0 bar and the farmer practice. However, the shortest plants were obtained from treatments irrigated at high water deficit i.e. 1.5 bars and 50% modified Penman.

These results indicate that the growth of potato plants is favoured by high soil moisture level and decreased by prolonged irrigations. It is worthy to mention that the height of potato plant observed from farmer practice is similar to those obtained from moderate water stress. These results may indicate that farmers water their fields at moderate soil moisture stress which may affect the plant growth.

In this respect, Slatyer (1973), pointed out that the growth and development of plants depend upon continuance cell division, the differentiation and enlargement of cells until the characteristic form of the plant is realized. However, Salter and Goode (1967) concluded that cell division appears less sensitive to water deficit than enlargement. It is worthy to mention that the period from 50 up to 80 days after planting seemed to be the maximum stage in the increase in plant height.

4.1.1.2. **Number of branches :**

Number of branches for potato plant through its growth cycle during the period of study is recorded in Table (6). Results indicate that number of b ranches / plant increased gradually from planting till the last sample (80 days after planting). The period from emergence up to 50 days after planting was found to be the maximum stage of branching as more than 75% of total number of branches were formed through such period. Fall plantation showed a higher number of branches/plant compared with the summer cultivation. This pattern can be related to climatic conditions. These findings may prove that potato plant directed its growth in fall plantation for producing shorter plants with higher number of branches, while in summer, the plants are taller with less number of branches.

Statistical analyses of variance showed that water deficit had a significant effect upon number of branches/plant. The maximum values of branches were produced from the wet treatment with a significant difference between it and the other irrigation treatments. However, the lowest values were gained from prolonged irrgation intervels i.e. modified Penman and 1.5 bars.

The Farmer practice treatment and that irrigated at 1.0

Table (6): **Effect of soil moisture stress on number of branches at various stages of potato growth cycle.**

Treatments	Season 1989-1990			Season 1990-1991			Mean of two seasons			Relative increase %		
	Days after planting											
	50	65	80	50	65	80	50	65	80	50	65	80
	Summer plantation											
Farmer practice	2.0	2.6	2.6	1.6	3.0	3.3	1.8	2.8	3.0	61	95	100
0.5 bar	3.6	4.0	4.3	2.3	3.6	3.6	3.0	3.8	4.0	75	96	100
1.0 bar	2.3	3.0	3.3	1.6	2.6	3.0	2.0	2.8	3.2	63	88	100
1.5 bars	1.6	2.3	2.6	1.3	2.3	2.3	1.5	2.3	2.5	59	94	100
50%Modified Penman	1.6	2.6	2.6	1.3	2.3	2.6	1.5	2.5	2.6	56	94	100
L.S.D. at 5%	0.8	0.7	N.S	N.S	N.S	N.S	0.1	0.4	N.S			
	Fall plantation											
Farmer practice	3.6	4.0	5.0	2.3	2.6	3.3	3.0	3.3	4.2	71	80	100
0.5 bar	4.6	5.3	5.6	3.6	4.3	5.3	4.1	4.8	5.5	75	88	100
1.0 bar	3.6	3.6	5.0	3.0	2.6	3.3	3.3	3.1	4.2	80	75	100
1.5 bars	3.0	3.3	3.6	1.3	2.0	2.3	2.2	2.7	3.0	73	90	100
50%Modified Penman	2.0	3.0	3.3	1.3	2.0	2.3	1.7	2.5	2.8	60	89	100
L.S.D. at 5%	1.3	0.9	1.2	1.0	0.9	1.0	0.7	0.5	1.0			

bar have intermediate values of number of branches/plant. These results indicate that wet conditions enhanced the growth of potato plant thereby increased its branches. On the contrary, severe water deficit restricted the branching of the plants. It can be mentioned that the effect of soil moisture stress on number of branches/plant was found to be less in its effect on summer plantation compared with fall one, In this connection, Taha (1978), concluded that in vegetable crops the growth of roots was less affected by water shortage than aerial parts.

4.1.1.3. Leef area :

Leaf area/plant during different periods of potato growth in the two plantations as influenced by water deficit is presented in Table (7). The percentage increase in total leaf area/plant for the average of the two seasons is illustrated in the same table. Leaf area/plant increased gradually from emergence to the last sampling date (80 days after planting). This trend was found to be clear in fall plantation. However, in summer, a slight decrease in leaf area was observed at the age of 80 days. Such decrease in leaf area/plant at this age, may be related to loss of some leaves. It can be mentioned that the growth period in summer is less than fall plantation. This means that the plants start to mature earlier in summer plantation compared with

Table (7): Effect of soil moisture stress on leaf area (cm^2) of potato at various stages of growth.

Treatments	Season 1989-1990			Season 1990-1991			Mean of two seasons			Relative increase %		
	Days after planting											
	50	65	80	50	65	80	50	65	80	50	65	80
	Summer plantation											
Farmer practice	4637	5919	5596	3959	5988	5581	4298	5954	5589	77	107	100
0.5 bar	4974	7553	6983	4285	7670	6909	4630	7612	6946	67	110	100
1.0 bar	4864	5532	5143	3917	6020	5909	4391	5776	5526	79	105	100
1.5 bars	3965	4351	3963	2927	4151	3990	3446	4251	3977	87	107	100
50%Modified Penman	3728	4072	3988	2894	4081	3901	3311	4077	3945	84	103	100
L.S.D. at 5%	17	21	15	16	20	18	11	13	11			
	Fall plantation											
Farmer practice	3198	4830	5071	2881	4418	4963	3040	4624	5017	61	92	100
0.5 bar	4103	5399	6751	3429	6980	7063	3766	6190	6907	55	90	100
1.0 bar	3266	4735	5039	2321	4186	5009	2794	4461	5024	56	89	100
1.5 bars	2803	3875	4341	2070	3385	3929	2437	3630	4135	59	88	100
50%Modified Penman	2731	3372	3783	1996	3163	3774	2364	3268	3779	63	87	100
L.S.D. at 5%	13	18	32	16	24	26	9	15	18			

fall one. It is worthy to mention that the gradual increase in leaf area as the plant developed is mainly due to the production of new leaves as well as to the expansion of such leaves.

Regarding the role of water deficit on the values of leaf area/plant, results indicate that soil moisture stress had a significant effect on leaf area/plant. The wet treatment (irrigated at 0.5 bar) had the highest values of leaf area/plant followed by plants watered at 1.0 bar or medium water stress. The difference between those water levels were found to be significant. The lowest leaf area/plant gained from severe water deficit or those plants either irrigated at 1.5 bars soil moisture tension or the treatment watered by estimated values of water consumption from Penman method. It can be mentioned that leaf area/plant gained from farmer practice are similar to that observed in medium soil moisture level. Such results may prove that wet conditions favoured the growth of plants i.e. the production of new leaves and their expansion. It can be concluded that potato grown well under wet soil moisture rather than medium or dry conditions. The previous results are mainly due to the effect of water deficit on the reduction of turger. Reduction in turger causes reduction in cell enlargement, which in turn decreases leaf enlargement.

In this connection Kramer (1977) concluded that plants subjected to water stress not only show a general reduction in size but also exhibit characteristic modifications in structure particularly of the leaves. The same author added that leaf area, cell size and intercellular volume are usually decreased.

4.1.1.4. Dry matter accumulation :

Dry matter accumulation in the various plant parts during its growth cycle can be considered as indirect measurment of physiological activities of these parts. Such dry matter is a good expression of plant growth.

a) Dry matter of leaves :

Dry matter of potato leaves throughout its growth cycle in the two plantations during the period of study as affected by soil moisture stress is presented in Table (8). The mean values of the two seasons as well as the percentage increase are recorded in the same Table. Dry matter of potato leaves started with lower values and increased gradually up to the last sampling time. This trend was found to be clear either in the two plantations as well as in the two seasons of study. Such pattern is mainly due to the development of the plant and the formation of new leaves. It is worthy to mention that the maximum period of dry matter accumulation by

Table (8): **Effect of soil moisture stress on dry weight (gm) of potato leaves at various stages of growth.**

Treatments	Season 1989-1990			Season 1990-1991			Mean of two seasons			Relative increase %		
	Days after planting											
	50	65	80	50	65	80	50	65	80	50	65	80
	Summer plantation											
Farmer practice	11.6	25.6	27.5	11.3	25.3	28.7	11.5	25.5	28.1	41	91	100
0.5 bar	13.5	28.3	30.3	12.9	29.3	30.7	13.2	28.8	30.5	43	94	100
1.0 bar	12.0	26.8	29.4	11.9	20.9	30.2	12.0	23.9	29.8	40	80	100
1.5 bars	10.9	23.0	24.9	8.3	18.4	19.6	9.6	20.7	22.3	43	93	100
50%Modified Penman	8.9	20.9	21.1	8.6	16.9	21.2	8.8	18.9	21.2	41	89	100
L.S.D. at 5%	3.0	N.S	2.1	2.7	3.4	6.2	1.8	2.1	2.9			
	Fall plantation											
Farmer practice	16.7	31.5	36.4	17.9	21.0	30.3	17.3	26.3	33.4	52	79	100
0.5 bar	20.6	40.5	52.9	20.5	33.4	54.1	20.6	37.0	53.5	39	69	100
1.0 bar	15.2	29.4	36.2	17.2	20.2	27.2	16.2	24.8	31.7	51	78	100
1.5 bars	13.4	21.4	28.0	15.9	17.7	24.9	14.7	19.6	26.5	55	74	100
50%Modified Penman	12.3	21.2	26.5	15.5	16.9	23.5	13.9	19.1	25.0	56	76	100
L.S.D. at 5%	2.0	2.5	7.2	2.1	4.9	5.5	1.4	2.4	4.9			

leaves was from emergence up to 50 days in fall while in summer it was from 50 to 65 days. In such periods more than 50% of total leaves dry matter was formed. The earlier period observed in fall plantation compared with summer season can be ascribed to low air temperature prevailing in the period of emergence in summer plantation. Also the period from planting to full emergence in fall was found to be less than summer. After these periods (50 days, in fall and 65 days in summer) the dry matter is translocated from the donner (leaves) to the storage organ i.e. tubers. Concerning the effect of soil moisture stress on leaves dry matter of potato plant during its growth cycle results showed that it had a significant effect on such character.This significant effect was found to be clear in the three sampling periods either in fall or summer cultivations. Increasing water deficit resulted in a significant reduction in dry matter accumulation in leaves. Such pattern of findings may prove the importance of maintaining soil moisture at a high level for better growth of plants.

The highest dry matter content of leaves was scored from the wet soil moisture treatment (0.5 bar) followed by the medium or farmer practice. However, the lowest values of leaves dry matter was produced from severe water deficit i.e. 1.5 bars of that estimated by Penman method.

The previous results are in full agreement with those reported by Ramadan (1979) who pointed out that dry matter percentage tended to increase with higher soil moisture, particularly in leaves.

Jeaferies and Mackerron (1989) concluded that the reduction in dry matter accumulation in crops grown under water stress was attributed primarly to lower interception of radiation as a result of reduced leaf expansion and the superession of branching. Parker (1968) pointed out that leaves are often the most sensitive part of the plant to drought and at the same time they are essential for the process of food manufacture. Kramer (1977) concluded that the most pervious effect of drought is to reduce photosynthetic surface and the production of dry matter. The large decrease in photosynthesis per unit of leaf area which occurs in plants subjected to water stress is usually attributed to stomatal closure.

b) Stems dry matter :

Stems dry matter of potato plant during different periods of growth is illustrated in Table (9).

The mean values as well as the percentage increase were calculated and presented in Table (9). Results clearly indicate that the values were low early in the season when

Table (9): **Effect of soil moisture stress on dry weight (gm) of potato stems at various stages of growth.**

Treatments	Season 1989-1990			Season 1990-1991			Mean of two seasons			Relative increase %		
	Days after planting											
	50	65	80	50	65	80	50	65	80	50	65	80
	Summer plantation											
Farmer practice	10.6	18.2	22.1	14.1	20.7	21.6	12.4	19.5	21.9	57	89	100
0.5 bar	13.2	20.8	28.5	17.3	25.4	27.4	15.3	23.1	28.0	55	83	100
1.0 bar	11.0	19.0	20.7	14.9	21.5	23.2	13.0	20.3	22.0	59	92	100
1.5 bars	9.8	15.4	17.8	11.2	19.7	23.7	10.5	17.6	20.8	50	85	100
50%Modified Penman	10.0	12.4	16.5	12.3	19.4	22.5	11.2	15.9	19.5	57	82	100
L.S.D. at 5%	**N.S**	3.1	4.9	2.5	3.0	2.2	1.5	1.8	2.5			
	Fall plantation											
Farmer practice	11.2	16.5	23.9	15.5	17.1	22.5	13.4	16.8	23.2	58	72	100
0.5 bar	18.5	24.2	34.0	16.1	19.3	26.1	17.3	21.8	30.1	57	72	100
1.0 bar	10.9	16.0	21.7	15.1	16.7	20.1	13.0	16.4	20.9	62	78	100
1.5 bars	10.1	15.3	18.3	9.9	11.3	16.4	10.0	13.3	17.4	57	76	100
50%Modified Penman	9.6	12.9	15.9	8.1	9.3	13.8	8.9	11.1	14.9	60	74	100
L.S.D. at 5%	1.7	2.7	3.0	2.0	4.8	4.4	1.3	2.6	2.3			

plants are small and increased gradually by the development of the plants up to the last sampling time (80 days after planting).

The grand period of dry matter accumulation in stem was found to be from emergence up to 50 days as about 60% of total dry matter of stems is formed through such period. This pattern is quite clear in both plantations.

Regarding the role of soil moisture on stems dry matter, results indicate that water deficit had a significant response on stems dry weight. This trend was found to be true in all plantations as well as in the two seasons of study. The growth of stems was enhanced by wet conditions and decreased by increasing water deficit. The results obtained with stems are similar to those observed from leaves dry matter. It can be concluded that frequent irrigation enhanced the growth of potato plant which was reflected on the accumulation of dry matter in stems. The maximum stem dry matter was observed from the treatment irrigated at 0.5 bar. Other stressed treatments produced less stems dry matter and that depending on the water deficit. In this respect, Wolfe et al. (1982) pointed out that water stress reduced dry matter production and attributed that to reduced leaf area and leaf area duration.

c) **Tubers dry matter :**

Tuber dry matter of potato plant during different periods of plant growth is recorded in Table (10). The mean values of the two seasons (in the two plantations) as well as the relative increase were calculated and presented in Table (10). It can be mentioned that dry matter of tubers increased gradually by time up to the end of the season. Such trend is may be due to formation of new tubers as well as to the increase in the storage of reserved food in tubers. The above mentioned results indicate that the translocation of food reserve continued till the last period (Wolfe, 1982).

The highest proportion of dry matter accumulation in tubers falls in the period from 50 up to 80 days after planting. In such periods more than 60% of tubers dry matter accumulated.

Regarding the role of soil moisture stress on tubers dry matter, results obtained are similar to those reported either with leaves or stems dry matter. In other words, increasing water deficit did result in decreasing the accumulation of reserved food in tubers which may be reflected on final yield. The highest tubers dry weight was scored from wet treatment and the lowest values were gained from severe water stress whereas other treatments falls in between.Such finding

Table (10): Effect of soil moisture stress on tubers dry weight(gm/plant) at various stages of potato growth.

Treatments	Season 1989-1990			Season 1990-1991			Mean of two seasons			Relative increase %		
	Days after planting											
	50	65	80	50	65	80	50	65	80	50	65	80
	Summer plantation											
Farmer practice	16.6	51.1	89.6	17.4	49.2	93.6	17.0	50.2	91.6	19	55	100
0.5 bar	17.8	68.4	106.7	24.5	74.2	121.7	17.4	71.3	114.2	15	62	100
1.0 bar	15.9	46.5	76.1	16.9	52.6	85.0	16.4	49.6	80.6	20	62	100
1.5 bars	9.4	34.0	58.0	15.1	38.3	63.8	12.3	36.2	60.9	20	59	100
50%Modified Penman	11.9	33.6	56.9	14.7	40.3	62.5	13.3	37.0	59.7	22	62	100
L.S.D. at 5%	0.8	3.0	3.8	2.9	6.1	5.4	1.2	3.5	3.9			
	Fall plantation											
Farmer practice	21.9	82.8	124.5	-	59.0	103.5	11.0	70.9	114.0	10	62	100
0.5 bar	29.2	94.5	144.3	-	66.4	112.8	14.6	80.5	128.6	11	63	100
1.0 bar	21.7	77.5	117.9	-	55.8	100.4	10.9	66.7	109.2	10	61	100
1.5 bars	17.6	66.8	96.4	-	45.6	80.4	8.8	56.2	88.4	10	64	100
50%Modified Penman	15.1	66.2	94.6	-	43.6	78.6	7.6	54.9	86.6	9	63	100
L.S.D. at 5%	7.4	8.3	11.0	-	4.3	8.9	N.S	4.9	9.2			

may prove that dry matter accumulation is favoured by aboundance of soil water and plant growth is inhibited under dry conditions.

In this respect, Levy (1985) concluded that drought stress imposed at early stage of tuber growth had little effect on dry matter, whereas stress imposed later, resulted in significant losses of dry matter.

d) Whole plant dry matter :

Total dry matter production by potato plant through-out its growth cycle under the irrigation treatment is presented in Table (11). The accumulation of dry matter by potato plant increased gradually from planting up to the last sample (80 days). Such results are similar in both plantations.Soil moisture stress had a significant effect on dry matter of whole plant. Decreasing water deficit or frequent irrigation enhanced the accumulation of dry matter and the reverse trend was found to be true. In other words, prolonged irrigation intervals decreased such accumulation and as soil moisture stress increased, a similar decrease in dry matter of whole plant was observed previously with different plant organs i.e. leaves, stems and tubers. These results indicate the importance of water availability for potato plant growth which can be detected from its dry matter

Table (11): Effect of soil moisture stress on whole plant dry matter (gm) at various stages of potato growth.

Treatments	Season 1989-1990			Season 1990-1991			Mean of two seasons			Relative increase %		
	Days after planting											
	50	65	80	50	65	80	50	65	80	50	65	80
	Summer plantation											
Farmer practice	38.8	94.9	139.2	42.8	95.2	142.9	40.8	95.1	141.1	29	67	100
0.5 bar	44.5	117.5	165.5	54.7	128.9	179.8	49.6	123.2	172.7	29	71	100
1.0 bar	38.9	92.3	126.2	43.7	95.0	130.9	41.3	93.7	128.6	32	73	100
1.5 bars	30.1	72.4	100.7	34.6	76.4	107.1	32.4	74.4	103.9	31	72	100
50%Modified Penman	30.8	66.9	94.5	35.6	76.6	106.2	33.2	71.8	100.4	33	72	100
L.S.D. at 5%	1.8	3.0	5.5	4.0	6.9	7.5	2.9	3.1	3.7			
	Fall plantation											
Farmer practice	49.8	130.8	184.8	33.4	97.1	156.3	41.6	114.0	170.6	24	67	100
0.5 bar	68.3	159.2	231.2	36.6	119.1	193.0	52.5	139.2	212.1	25	66	100
1.0 bar	47.8	122.9	175.8	32.3	92.7	147.7	40.1	107.8	161.8	25	67	100
1.5 bars	41.1	103.5	142.7	25.8	74.6	121.7	33.5	89.1	132.2	25	67	100
50%Modified Penman	37.0	100.3	137.0	23.6	69.8	115.9	30.3	85.1	126.5	24	67	100
L.S.D. at 5%	9.4	10.0	10.7	3.4	6.1	11.2	4.4	5.3	5.9			

accumulated in different period of its growth. In the light of the previous results, it can be concluded that the availability of soil water is one of the cheif constrains on the production of dry matter. Total photosynthesis is determined by light, CO_2, water and nutrient supply, by the growth stage of the plant which determines both photosynthesis rate and the reinvestment rate and the response of the plant to water deficit. Potato plant seemed to grow well under wet conditions rather than dry one.

4.1.2. Potato yield :

4.1.2.1. Tuber characters :

Some measurements of tubers were studies i.e. width, length, ratio between length/width, number of tubers/plant, average tuber weight/plant, dry matter percentage, specific weight and total soluble solids in samples collected from final yield and recorded in Table (12).

a) Tuber length and width :

Results of length and width of potato tubers showed that both measures were affected significantly by water deficit. The highest values of either length or width of tubers were attained from treatments irrigated frequently i.e. at 0.5, 1.0 bar or farmer practice without any significant differences between them. However, other prolonged

Table (12): Effect of soil moisture stress on some tuber characters of potato plant in summer and fall plantation.

Treatments	Summer plantation						Fall plantation					
	Farmer prac-tice	0.5 bar	1.0 bar	1.5 bars	50% M.P.	L.S.D 5%	Farmer prac-tice	0.5 bar	1.0 bar	1.5 bars	50% M.P.	L.S.D 5%
Season 1989-1990:												
Width of tuber(cm)	11.80	10.99	11.10	10.84	11.30	0.39	11.40	11.90	11.30	9.55	10.15	0.90
Length of tuber(cm)	15.20	16.10	15.30	10.91	10.01	N.S	15.50	16.11	15.90	11.30	10.88	0.70
Tuber index=length/width	1.29	1.46	1.38	1.01	1.05	N.S	1.36	1.35	1.41	1.18	1.07	N.S
Number of tuber/plant	5.00	5.30	5.00	5.00	4.00	N.S	6.00	6.66	6.33	4.99	5.00	N.S
Tuber yield/plant(kg)	0.60	0.84	0.66	0.48	0.45	0.17	0.80	0.95	0.79	0.57	0.55	0.30
Average tuber weight(kg)	0.12	0.16	0.13	0.10	0.11	N.S	0.13	0.14	0.12	0.11	0.11	0.02
Tuber dry weight %	25.90	23.50	26.13	27.05	27.13	0.41	21.00	20.99	21.50	20.90	21.30	0.27
Tuber specfic weight	1.14	1.10	1.13	1.09	1.10	N.S	1.06	1.01	1.06	1.08	1.07	N.S
Total soluble solids	5.73	4.73	5.80	5.40	5.20	N.S	5.66	5.90	6.00	5.80	6.20	N.S
Season 1990-1991:												
Width of tuber(cm)	11.93	12.00	12.40	10.13	10.02	0.49	11.74	11.88	11.79	9.95	10.88	0.90
Length of tuber(cm)	15.30	15.93	15.55	11.83	12.77	0.66	16.90	16.70	16.80	12.75	14.40	1.10
Tuber index=length/width	1.28	1.33	1.25	1.17	1.27	N.S	1.44	1.40	1.42	1.28	1.32	N.S
Number of tuber/plant	5.33	5.33	4.66	4.00	4.80	N.S	4.33	5.00	3.30	4.33	4.00	N.S
Tuber yield/plant(kg)	0.69	0.88	0.68	0.55	0.52	0.14	0.92	1.07	0.91	0.62	0.60	0.24
Average tuber weight(kg)	0.13	0.17	0.15	0.14	0.13	0.09	0.21	0.21	0.28	0.14	0.15	0.04
Tuber dry weight %	26.10	24.90	26.89	27.90	27.93	0.33	24.55	23.82	26.42	26.40	26.70	0.29
Tuber specific weight	1.08	1.02	1.09	1.11	1.08	N.S	1.04	1.01	1.03	1.06	1.08	N.S
Total soluble solids	5.60	5.76	5.60	5.60	5.60	N.S	5.63	5.56	5.66	5.73	5.66	N.S
Mean of two seasons :												
Width of tuber(cm)	11.86	11.49	11.75	10.48	10.66	0.30	11.57	11.89	11.54	9.75	10.51	0.63
Length of tuber(cm)	15.25	16.01	15.42	11.37	11.39	0.39	16.20	16.40	16.35	12.02	12.64	0.59
Tuber index=length/width	1.28	1.39	1.31	1.09	1.16	N.S	1.40	1.37	1.41	1.23	1.19	N.S
Number of tuber/plant	5.17	5.30	4.83	4.50	4.00	N.S	5.17	5.83	4.82	4.66	4.50	N.S
Tuber yield/plant(kg)	0.65	0.86	0.67	0.52	0.48	0.21	0.86	1.01	0.85	0.60	0.58	0.16
Average tuber weight(kg)	0.13	0.17	0.14	0.15	0.12	0.05	0.17	0.18	0.20	0.14	0.15	0.02
Tuber dry weight %	26.00	24.20	26.51	27.47	27.53	0.24	22.77	22.40	23.96	23.65	24.00	0.12
Tuber specific weight	1.11	1.06	1.11	1.10	1.09	N.S	1.05	1.01	1.04	1.07	1.08	N.S
Total soluble solids	5.66	5.24	5.70	5.50	5.40	N.S	5.64	5.73	5.83	5.76	5.93	N.S

irrigation intervals (1.5 bars or 50% modified Penman treatments) resulted in decreasing such values. Such decrease in tuber length or width was found to be significant compared with those treatments irrigated frequently. These findings can be related to the effect of water deficit on the trans-location of carbohydrates which affected the final size of potato. Thus, it can be concluded that maintaining soil moisture at high level produces larger tubers (Ramadan ,1979).

b) Tuber index (length/width) :

Tuber index or the ratio between length and width under the effect of various irrigation treatments is presented in Table (12). Results showed that tuber index ranged from 1.02 up to 1.46. Statistical analyses showed that water deficit did not affect the values of tuber index. However, results clearly indicate that frequent irrigations or watering potato plants at low or moderate stresses increased the values of tuber index. On the contrary, severe soil moisture stress resulted in decreasing such values. These results indicate that potato tubers are some what spherical in shape when grown under low soil water, while under high soil moisture level, the tuber length was much more than its width. Photo No. (1) shows the differences in tuber shape under the various irrigation treatments.

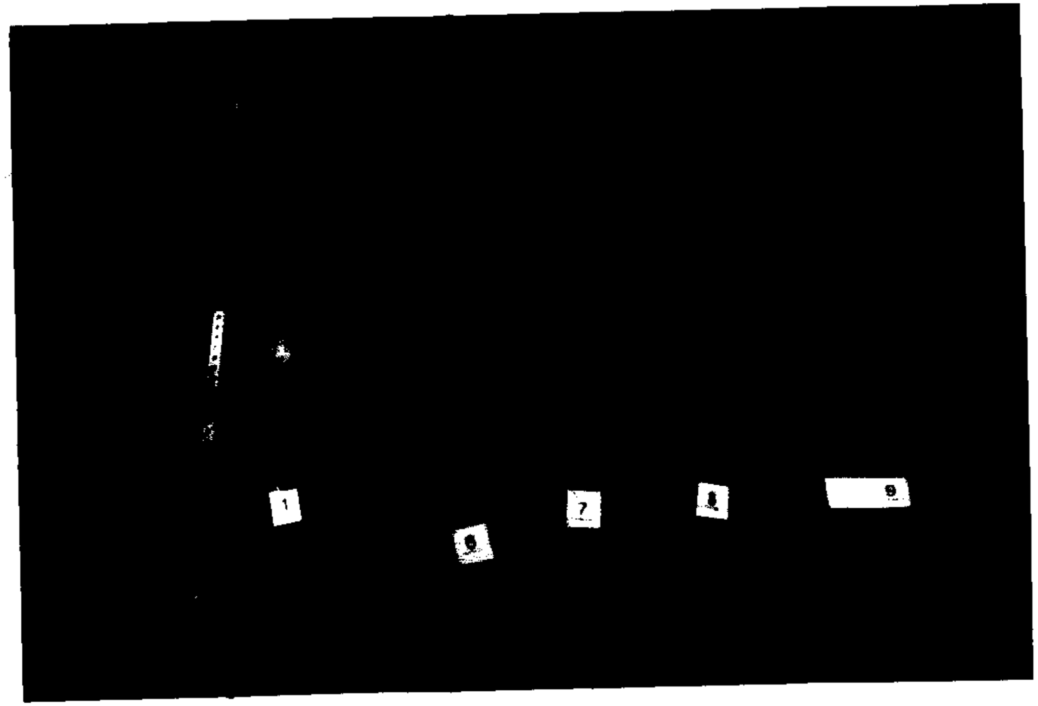


Photo No. (1) **Effect** of soil moisture stress treatments* on tuber shape and size.

* 1) **Farmer** practice. 6) 0.5 bar
7) 1.0 bar 8) 1.5 bars
9) 50% Modified **Penman**.

It can be concluded that low water deficit produce larger tubers and longer in length compared with those plants grown under severe soil moisture stress (Levy, 1985).

c) **Number of tubers/plant :**

Table (12) represent the number of tubers per plant as affected by water stress. Results clearly indicate that water deficit did not significantly affect number of tubers/plant. However, number of tubers/plant seemed to be greater under low and medium soil moisture stress, while slightly decreased under severe water deficit (Ramadan, 1979).

This trend of results was found to be true either in fall or summer plantation and in the two seasons of study. Thus, it can be concluded that number of tubers/plant is mainly controlled by genetics and to less extent by environmental factors. It is worthy to mention that number of tubers/plant ranged from 4 to 5 tubers.

d) **Tuber yield/plant :**

Tuber yield/plant under different irrigation treatments is shown in Table (12). Statistical analysis indicate that the yield of tubers/plant was significantly affected by water deficit. Such pattern of results was found to be the same in both plantations and through the period of study. Maximum tuber yield/plant was scored from the wet treatment (0.5 bar) followed by medium soil moisture stress regime (1.0 bar or farmer practice). However, the lowest tuber yield/plant was attained from dry treatments i.e.severe water stress (1.5 bars or 50% modified Penman).

These results indicate the importance of soil water for maximum production of tubers. It can be mentioned that the differences between the 0.5 bar treatment and other irrigation treatments are significant. In this connection Bartoszuk (1987) concluded that when soil moisture stress duration increased tuber yield/plant was decreased specially at peak flowering period. It is worthy to mention that tuber yield/plant in fall plantation was found to be greater than that observed in summer season.

e) Average tuber weight :

Average tuber weight data showed that it was higher in fall plantation compared with summer one. This pattern of finding was found to be similar in both seasons. Soil moisture stress had a significant response on tuber weight, in both plantations as well as in the two seasons of study. The highest value of tuber weight was gained from the wet treatment followed by medium soil moisture stress (irrigated at 1.0 bar) without significant differences between them in fall plantation. However, the differences were found to be significant in summer plantation. The lowest tuber weight was obtained from other irrigation treatments i.e. farmer practice, 1.5 bars and 50% modified Penman, without any significant differences between them. It can be stated that the differences between the previous mentioned treatments and the wet soil moisture level were found to be significant. These results indicate that soil moisture comprise an important factor in the production of potato plant. The heaviest tuber weight was gained by irrigating potato plant frequently or maintaining the plants under high soil moisture level, while the reverse trend can be achieved by low soil moisture level.

Table (12) represent the effect of water stress on the percentage of tuber dry weight. Results indicate that water deficit had a significant effect upon tuber dry weight percentage. These findings were found to be true in both plantation i.e. fall or summer cultivation. Data indicate that increasing water deficit did result in a significant increase in total dry matter of potato tubers. Such pattern may prove that potato plants subjected to drought conditions produce tubers less in its moisture content. In other words, the plants imposed to severe water deficit, had a higher dry matter percentage compared with those plants irrigated frequently or growing under moist conditions. These results are in full agreement with those reported by El Motaz et al. (1970) who found that dry matter percentage of potato tubers were higher under prolonged irrigation intervals.

g) Tuber specific weight :

Table (12) showed the effect of water deficit on tuber specific weight. Statistical analysis of the variance indicate that soil moisture stress had no response on such character. The values of tuber specific weight ranged from 1.01 to 1.08 in fall plantation while from 1.06 to 1.11 in summer plantation. It can be concluded that water deficit did not affect tuber specific weight.

h) Total soluble solids :

Total soluble solids of potato tubers under the various irrigation treatments were tested and presented in Table (12). The values ranged from 5.64 to 5.93 for fall plantations. As for summer, mean values ranged from 5.24 to 5.70. It can be concluded that water deficit, did not affect total soluble solids values in either fall or summer plantation, and the values are about the same.

4.1.2.2. Tuber production :

Potato tuber yield expressed as tons/feddan in the two seasons as well as in both plantations as influenced by different soil moisture is presented in Table (13).

Results of Table (13) clearly indicate that tuber production in fall cultivation was found to be more than summer. This pattern was the same in both seasons. In this respect Ramadan (1979) reported that summer tuber yield always suppressed the respective one of fall plantation.

Zoromba (1988) showed that winter potato out-yielded summer plantation. With regardsto the role of water deficit on tuber production, analysis of variance showed that irrigation treatments had a highly significant effect on tuber yield. Such significant effect was found to be true either in both plantations or in the two seasons of study.

The maximum tuber yield was scored from the wet treatm-ent (irrigated at 0.5 bar, soil moisture tension) followed by the medium soil moisture stress (irrigated at 1.0 bar, soil moisture tension) and the farmer Practice treatment. However, the least tuber production was gained from the dry treatment which was irrigated at 1.5 bars, soil moisture tension and that treatment having irrigation at 50% modified Penman. The previous results are the same in both plantations and in the two seasons of study. The increase in tuber yield

Table (13): **Effect** of soil moisture stress on tuber yield (Ton/feddan)

Treatments	Summer plantation			Fall plantation		
	Season 1989-90	Season 1990-91	Mean of Two seasons	Season 1989-90	Season 1990-91	Mean of two seasons
Farmer practice	9.52	11.04	10.28	14.72	12.80	13.76
0.5 bar	13.44	14.08	13.76	17.04	15.20	16.12
1.0 bar	9.04	10.88	9.96	14.48	12.64	13.56
1.5 bars	7.68	8.72	8.20	9.92	9.12	9.52
50% Modified Penman	7.20	8.24	7.72	9.60	8.80	9.20
L.S.D. at 5%	1.70	1.20	1.02	2.10	1.90	1.32

gained from the wet treatment was found to be significant over the other irrigation treatments.

These results indicate that for maximum tuber yield of potato, irrigation water should be practiced at 0.5 bar soil moisture tension. However, more than that level, the yield of potato plant decreased significantly. It is worthy to mention that the values obtained from the medium soil moisture stress (1.0 bar), and farmer practice are about the same. This means that the farmers irrigate their fields at moderate stress which affect the final tuber production. Also, no significant differences were observed between the dry treatment (irrigated at 1.5 bar, severe water stress) and that treatment watered at 50% modified Penman. These results prove that soil moisture stress affects the production of tubers. For maximum tuber yield, irrigation water must be practiced frequently at 0.5 bar soil moisture tension. The results obtained previously can be attributed to the effect of water deficit on plant growth therby on final yield. In this connection Kramer (1977)stated that water stress reduced photosynthesis by closure of stomata, which decreases the supply of CO_2, but water stress reduces also the capacity of the protoplasm to carry on photosyntheses. The reduction in photosyntheses decreased translocation of carbohydrates, and distrubance of nitrogen metabolism, all added to the effects of reduced turger in reducing growth. In turn, reduced growth reduces the photosynthetic surface, further decreasing the relative amount of carbohydrates available for growth, as compared with unstressed plants.

The previous results are in full agreement with those reported by Ramadan (1979) who concluded that maximum yield was obtained from plants irrigated when 50% of available moisture was depleted in summer and fall plantations. Jorgensen (1984) found that frequent irrigation i.e. at 0.4 bar produced the highest tuber yield over the stressed treatments. Amer et al (1992) reported that the yield of potato positively responsed to the increase in water applied under sprinkler system.

The grading of the tubers to different grades has been evaluated and expressed as a percentage of total yield. Such results are presented in Table (14). Table (14) illustrates the potato size percentage. Four groups were used in grading potato yield i.e. less than 35 mm, 35-45 mm, 45-60 mm and more than 60 mm. As a general, more than 60% of tubers falls in the last two grades i.e. 45-60 mm and more than 60 mm. Also, fall plantation produced larger tubers than that of summer plantation. This means that the fall plantation was superior in producing larger tubers in size compared with

Table (14): Effect of soil moisture stress on the grading of potato tubers as a percentage of final yield.

Treatments	Season 1989-90				Season 1990-91				Mean of two seasons			
	Less than 35mm	35-45 mm	45-60 mm	More than 60mm	Less than 35mm	35-45 mm	45-60 mm	More than 60mm	Less than 35mm	35-45 mm	45-60 mm	More than 60mm
Summer plantation												
Farmer practice	12.36	16.01	35.02	36.61	5.20	23.80	46.10	24.90	8.78	19.91	40.56	30.76
0.5 bar	11.71	15.47	34.09	38.73	4.30	16.00	46.40	33.30	8.01	15.74	40.25	36.02
1.0 bar	16.50	21.08	32.69	28.73	5.10	22.30	47.50	25.10	10.80	21.69	40.10	27.42
1.5 bars	17.31	37.13	25.66	19.90	9.10	39.50	29.90	21.50	13.21	38.32	27.78	20.70
50%Modified Penman	15.24	39.46	25.12	20.18	10.50	40.90	28.10	20.50	12.87	40.18	26.61	20.34
Fall plantation												
Farmer practice	3.95	9.46	45.10	41.49	4.10	7.91	35.90	52.09	4.03	8.69	40.50	46.79
0.5 bar	6.94	8.37	39.40	45.29	5.10	9.22	32.90	52.78	6.02	8.80	36.15	49.04
1.0 bar	3.40	8.10	48.41	40.09	3.00	11.10	39.30	46.60	3.20	9.60	43.86	43.35
1.5 bars	4.91	26.80	29.31	38.98	13.66	9.80	37.30	39.24	9.29	18.30	33.31	39.11
50%Modified Penman	8.50	19.90	38.50	33.10	13.50	16.80	36.50	33.20	11.00	18.35	37.50	33.15

tubers produced in summer plantation. It can be mentioned that tubers less than 35 mm in diameter does not exceed 10% in both plantations. With regards to the effect of water deficit on tuber size, results of Table (14) showed that high and medium soil moisture levels i.e. wet and those treatments irrigated at 1.0 bar or farmer practice produced the highest percentage of larger tubers. In those treatments more than 80% of tubers fall in medium and larger size percentage i.e. 45-60 and more than 60 mm. These results confirmed that potato plant requires adequate soil moisture level during growth and development. Such adequate soil moisture can be achieved by irrigating the plants at low or moderate soil moisture stresses. On the contrary, severe water deficit did result in decreasing the percentage of medium and larger tubers while increased the percentage of smaller tubers. These results mean that maintaining a high soil moisture level through the growth period of potato improved the production of tubers by producing larger tubers. The previous findings are in line with those reported by Ramadan (1979) who concluded that high soil moisture increased the large size tuber percentage, while the low soil moisture increased the small size in both seasons. Yadav and Tripathi (1972) found that the big size potato tubers were obtained when the available soil moisture increased. Moreover, Haverkort (1982), pointed out that, because of the variation of soil moisture, a restarting of tuberization results in formation of many small tuber.

4.1.3. Water Relations :

Evapotranspiration :

Evapotranspiration is the loss of water from plants and soil to the atmosphere. This process includes evaporation from soil and plant surfaces plus transpiration of water from the plant.

Meteorological factors such as radiation, temperature, relative humidity and wind velocity, control evaporation from free water surfaces. Factors related to the crop and the soil in addition to these meteorological factors affect evapotranspiration from a cropped soil (Rijtema, 1965).

However, Burman et al. (1980) defined evapotranspiration or water consumptive use as the combined process by which water is transfered from the earth surface to the atmosphere. It includes evaporation of water from the soil and plant plus transpiration of liquid water through plant tissues expressed as the latent heat transfer per unit area or its equivalent depth of water per unit area.

4.1.3.1. Actual evapotranspiration :

a) Seasonal rates :

A detailed summary of actual evapotranspiration by potato plant in fall and summer plantations during the period of study is presented in Tables(15 & 16). Seasonal water consumption by potato plant varies widely between 300.4 and 404.9 mm in the first season and between 310.2 and 419.3 mm in the second season for fall plantation. However, for summer plantation, seasonal water consumptive use ranged from 466.8 to 626.9 mm in the first season and from 443.4 to 619.9 mm in the second season. It can be mentioned that there is a slight variation in water consumptive use in the two seasons either in fall or summer plantation. Such slight differences are mainly due to the variations in climatic factors as well as the length of the growth period. In this connection Jensen (1968) pointed out that crops would not necessarily require the same amounts of water when grown under widely different climatic conditions. Water requirements of a crop can not be discussed without considering the crop season and potential evapotranspiration. Doorenbos and Kassam (1979) concluded that for high yields of potato, the water requirements (maximum evapotranspiration) for a 120 to 150 days growth period ranged from 500 to 700 mm, depending on climate. In recent studies, at Gemmeiza, Egypt, Ainer et al. (1993) have found that seasonal water consumptive use for fall plantation was

Table (15):- Effect of soil moisture stress on water consumptive use (mm) by potato plant for fall plantations.

Treatments	Oct.*	Nov. 1-15	Nov. 16-30	Dec. 1-15	Dec. 16-31	Jan. 1-15	Jan. 16-31	Feb.**	Total
	Season 1989-90								
Farmer practice	17.6	16.5	16.5	47.3	64.5	63.0	60.0	72.0	357.4
0.5 bar	20.8	19.5	21.7	52.5	76.4	77.2	70.8	66.0	404.9
1.0 bar	17.6	16.5	16.5	44.0	59.1	61.5	57.5	72.0	344.7
1.5 bars	17.6	16.5	16.5	40.7	52.8	48.3	48.0	60.0	300.4
50% Modified Penman	17.6	16.5	16.5	41.8	54.4	50.4	49.6	62.0	308.8
	Season 1990-91								
Farmer practice	30.0	18.0	20.7	58.5	64.8	61.1	59.2	51.8	364.1
0.5 bar	32.5	19.5	34.5	62.1	88.0	78.0	58.5	46.2	419.3
1.0 bar	30.0	18.0	20.5	55.5	66.2	61.6	56.0	49.0	356.8
1.5 bars	30.0	18.0	20.3	52.2	56.0	46.0	48.0	42.0	312.8
50% Modified Penman	30.0	18.0	20.2	51.0	56.4	46.6	48.0	42.0	310.2

* 16 Days (Season I)
25 Days (Season II)

** 20 Days (Season I)
14 Days (Season II)

Table (16):- **Effect of soil moisture stress on water consumptive use (mm) by potato plant for summer plantation.**

Treatments	Feb.*	Mars 3-15	Mars 16-31	April 1-15	April 16-30	May 1-15	May 16-31	June**	Total
	Season 1989-90								
Farmer practice	-	52.7	50.8	87.0	89.6	97.8	93.9	77.7	549.5
0.5 bar	-	55.1	54.4	75.4	112.2	121.1	118.3	90.4	626.9
1.0 bar	-	52.7	50.8	87.0	87.0	89.2	86.4	76.7	529.8
1.5 bars	-	52.7	49.1	61.5	71.3	83.1	79.1	70.0	466.8
50% Modified Penman	-	52.7	49.3	64.5	71.0	84.8	90.1	62.0	474.4
	Season 1990-91								
Farmer practice	26.6	42.0	61.3	73.6	87.0	99.4	95.2	51.5	536.6
0.5 bar	26.6	42.0	71.2	86.3	122.7	125.6	98.5	46.2	619.1
1.0 bar	26.6	42.0	63.5	78.3	86.2	91.2	90.4	51.3	529.5
1.5 bars	26.6	42.0	61.3	67.8	80.8	78.0	62.2	40.7	459.4
50% Modified Penman	26.6	42.0	61.3	65.3	76.5	66.9	67.6	46.2	443.4

*** 8 Days (Season I)**

****** 20 Days (Season I)
11 Days (Season II)

328.0, 293.0 and 374.0 mm respectively under surface, sprinkler and drip irrigation systems. Results of Tables(15 & 16) indicate that seasonal water use by potato plant in summer plantation was higher than that of fall. The increase in water consumption observed in summer plantation is mainly due to higher evaporative power of the air in summer months compared with winter months.

The values of potential evapotranspiration were higher in summer plantation than those of winter monthes (Tables 15 & 16). As a general, the values of potential evapotranspiration (expressed as mm) were low during winter months (Dec., Jan., and Feb.), while increased gradually after that. These results can be related to the increase in mean air temperature and solar radiation observed in March, April, May and June. Those factors are the main parameters in the calculation of potential evapotranspiration. Also, those factors resulted in increasing the evaporative power of the air.(Tables 3 & 4).

In this respect Chang (1971) showed that the rate of evapotranspiration depends on the evaporative power of the air as determined by temperature, humidity and net radiation. Ramadan (1979) in Egypt showed that summer plantation consumed more water than that of fall. As for summer, the total amount of water needed were from 1976-2038 m^3/feddan, while for fall it ranged from 1527-1787 m^3/feddan. Rgarding the effect of soil moisture stress on seasonal water use by potato plant in two plantation, results clearly indicate that water deficit affect greatly such values.

Seasonal water consumption by potato in fall plantation was 404.9, 357.4, 344.7, 300.4 and 308.8 mm respectively for irrigation treatments irrigated at 0.5 bar, farmer practice, at 1.0 bar, at 1.5 bars and 50% modified Penman in first season. The corresponding values of the second season were 419.3, 364.1, 356.8, 312.8 and 310.2 mm for treatments in the same order. As for the values of summer plantation, it were 626.9, 549.5, 529.8, 466.8, 474.4 mm for treatments irrigated at 0.5 bar, farmer practice, 1.0 bar, 1.5 bars and 50% modified Penman respectively. The respective values of the second season were 619.1, 536.6, 529.5, 459.4 and 443.4 mm for treatments in the same order. Results clearly indicate that water consumptive use increased as soil moisture stress decreased. In other wards, water consumption increased as soil moisture was kept wet by frequent irrigations and decreased by prolonged irrigation intervals. The least evapotranspiration was brought about under severe soil moisture stress (1.5 bars or 50% modified Penman).

However, the highest water use was attained under low water deficit (0.5 bar). Under moderate soil moisture stress the values fall in between (1.0 bar or farmer practice). This trend was found to be the same either in the two seasons or in two plantations i.e. fall or summer plantation. These results reveal that the increase in water consumptive use by potato depends upon the available soil moisture in the root zone prior irrigation. As soil moisture was kept wet by frequent irrigations, higher evapotranspiration was attained.

On the contrary, increasing soil moisture stress by prolonged irrigated intervals resulted in decreasing seasonal water consumption by potato plant. Such findings can be attributed to availability of soil water to the plants as well as at the soil surface which give an opportunity for high evaporation from wet soil rather than a dry one.

Tanner et al. (1960) stated that on a given type of soil, the total evapotranspiration depends on water available to the plants as well as to the soil surface, and upon total net radiation above plants and at the soil surface when water is readily available both to the plants and at the soil surface, maximum evapotranspiration obtains .

Wiegand (1962) pointed out that the drying rate of a bare soil is proportional to the water content and inversely proportional to time and a drying front advances into the soil linearly with time. When the capacity of the soil to conduct water to the surface does not equal the evaporative demand, the surface dries and a parallelic water distribution develops within the soil.

Doorenbos and Priutt (1977) pointed out that as the soil dried, the rate of water transmitted through the soil will reduce. At some stages, the rate of flow falls below the rate needed to meet crop evapotranspiration. This ET. crop will fall below its predicted level. The effect of soil water content on evapotranspiration varies with crop and is conditioned primarly by type of soil and water holding capacity, crop rooting characteristics and the meteorological factors determining the level of transpiration.

Ramadan (1979), in Egypt, showed that evapotranspiration rates increased as soil moisture increased. Rashid and Ahmad (1988) in trials on potato found that actual water consumption was 388, 365, 333 and 298 mm respectively for treatments irrigated at 40, 55, 70 and 85% available soil moisture. In this respect Anton (1991) concluded that soil moisture stress affects greatly seasonal evapotranspiration. As soil moisture stress increased by prolonged irrigation, seasonal water use decreased. The drier soil is the lower water consumption.

The discussion of evapotranspiration rates by plants under different water regimes covered their influences on resistance to evapotranspiration.

b) Daily rates :

Daily evapotranspiration rates by potato plant during its growth cycle in the two tested plantations i.e. fall and summer plantations through the period of study(two successive seasons) is presented in Tables (17 and 18). As a general trend, the values of daily evapotranspiration rates started with lower rates at the beginning of the growing season. Such trend is due to plant vegetation was not established yet (period of sprouts) and loss of moisture was mostly by evaporation. Thereafter, a gradual increase in daily rates of evapotranspiration was observed as potato plant grown up. This can be attributed to the vigorous growth of potato plant as it starts to cover the ground. Thus, daily evapotranspiration reached its maximum value when potato plants aged 90 days in fall and 75 days in summer plantation. These results indicate that the increase in evapotranspiration stood parallel to the increase in vegetative growth of the plant.

Table (17):- **Effect** of soil moisture stress on daily evapotranspiration (mm) of potato in fall plantation.

Treatments	Oct.	Nov. 1-15	Nov. 16-30	Dec. 1-15	Dec. 16-31	Jan. 1-15	Jan. 16-31	Feb.	Mean
	Season 1989-90								
Farmer practice	1.10	1.10	1.10	3.15	2.91	4.20	3.75	3.60	2.61
0.5 bar	1.30	1.30	1.45	3.50	4.78	5.15	4.43	3.30	3.15
1.0 bar	1.10	1.10	1.10	2.93	3.69	4.10	3.59	3.60	2.65
1.5 bars	1.10	1.10	1.10	2.71	3.30	3.22	3.00	3.00	2.32
50% Modified Penman	1.10	1.10	1.10	2.79	3.40	3.36	3.10	3.10	2.38
	Season 1990-91								
Farmer practice	1.20	1.20	1.38	3.90	4.05	4.07	3.70	3.70	2.90
0.5 bar	1.30	1.30	2.30	4.14	5.50	5.20	3.66	3.30	3.34
1.0 bar	1.20	1.20	1.37	3.70	4.14	4.11	3.50	3.50	2.84
1.5 bars	1.20	1.20	1.35	3.48	3.50	3.07	3.00	3.00	2.48
50% Modified Penman	1.20	1.20	1.35	3.40	3.40	3.11	3.00	3.00	2.46

Table (18):- **Effect** of soil moisture stress on daily evapotranspiration (mm) of potato in summer plantation.

Treatments	Feb. 21-28	Mars 1-15	Mars 16-31	April 1-15	April 16-30	May 1-15	May 16-31	June 1-15	June 16-20	Mean
	Season 1989-90									
Farmer practice	-	4.39	3.18	5.80	5.97	6.52	5.87	4.14	3.90	4.48
0.5 bar	-	4.59	3.40	5.03	7.48	8.07	7.39	4.96	4.00	5.62
1.0 bar	-	4.39	3.18	5.80	5.80	5.95	5.40	4.07	3.90	4.81
1.5 bars	-	4.39	3.07	4.10	4.75	5.54	4.94	3.69	3.68	4.27
50% Modified Penman	-	4.39	3.08	4.30	4.73	5.65	5.63	3.26	3.28	4.29
	Season 1990-91									
Farmer practice	3.33	2.80	3.83	4 91	5.80	6.63	5.95	4.68	-	4.74
0.5 bar	3.33	2.80	4.45	5.75	8.18	8.37	6.16	4.20	-	5.41
1.0 bar	3.33	2.80	3.97	5.22	5.75	6.08	5.65	4.66	-	4.68
1.5 bars	3.33	2.80	3 83	4.52	5.39	5.20	3.89	3.70	-	4.08
50% Modified Penman	3.33	2.80	3.83	4.35	5.10	4.46	4.23	4.20	-	4.04

In other words, the increase in water use rates is similar to the increase in crop cover percent. Also, such period is considered as the period of tuberization. Potato plant needs more water in this period as the tubers increased in size and weight. Thereafter, daily rates started to decrease through the period of pre-harvesting. It can be mention that the gradual increase in daily water use from planting to the period of tuberization can be explained on the basis of crop cover. When plants are small, they intercept little of net radiation thereby evaporation will be greater than transpiration. As the extent of plant cover, transpiration increased.

In this respect, Lemon et al. (1959) pointed out that the gradual increase in evapotranspiration from planting to maturity can be explained on basis of plant cover percent. The decrease in evapotranspiration after maturation is probably a plant-dependent factor. However, in many studies soil water is not mentioned at high level after maturation. Also, Ramadan (1979) concluded that monthly consumptive use of potato plant increased with age to a peak perior of tuber enlargement then gradually decreased with age. Monthly consumptive use was higher in the third month for fall season, while in summer plantation was high in the second and third months.

Soil moisture stress had a negative response on daily water consumption by potato plant (Tables 17 and 18). In other words, as soil moisture stress increased by prolonged irrigation, (water deficit treatments) a relative decrease in daily water use occured. Such phenomena is a function of water availability to the plants. In this respect, Black (1965) concluded that the independance of evapotranspiration and density of vegetation canopy exists for different reasons where soil is dry than where availability of water for evaporation and transpiration is unlimited. Under moist soil, the control is in the atmosphere. Under dry conditions the control is in the soil. Under intermediate conditions, the control may be partly in the soil and partly in the plants. Russell (1975) stated that "the drier soil, the lower is the maximum rate the roots can supply water to the leaves. Ramadan (1979), in trials with potato, pointed out that it is evident that in each month the consumptive use was higher when the water moisture was higher i.e. being the lowest in treatment A (irrigated at 75% depletion in available water) and the highest in treatment D (irrigated at 30% depletion). This trend was particularly more obvious in the early months relatively than the later ones and was more higher in summer than in fall plantation.

It can be concluded from the previous results that soil moisture stress affects greatly seasonal and daily water use by potato plant. As soil moisture stress increased, seasonal and daily evapotranspiration decreased. The drier the soil is the lower the water consumption by potato plant.

In this connection , Anton (1991) concluded that the discussion of water use rates by plants under different water regimes covered their influences on resistance to evapotranspiration. These effects can be grouped into three categories :

1. The influence of degree of crop cover or canopy that affects diffusive resistance.

2. The maturation of the crop may influence evapotranspiration by decreasing the portion of net radiation converted to latent heat of vaporization.

3. Net soil moisture stress prior to irrigation can influence the effective resistance. Low stress prior irrigation decrease the effective diffusive resistance.

4.1.3.2. Crop coefficeint (Kc) :

The term crop coefficient has been developed as the crop does not require much water for the whole season to meet potential evapotranspiration. Crop coefficient has been developed to reflect the physiology of the crop, the percent or the degree of crop cover on potential evapotranspiration. Such term is calculated as the dimensionless ratio of crop evapotranspiration and potential evapotranspiration. The growth season of potato plant can be defined to the following stages :

1. Initial stage : early growth (20 - 30 days) after planting.
2. Crop development stage (30 - 40 days) after Initial stage .
3. Mid season stage (30 - 45 days) after development stage .
4. Late season stage (20 - 25 days) after Mid season stage .
5. Maturation: after late season stage to maturity.

The crop coefficient of potato plant throughout its growth cycle in summer and fall plantations is presented in Tables (19).

The values were calculated according to the daily potential evapotranspiration estimated by Penman's method and actual water consumptive use derived from the wet treatment (irrigated at 0.5 bar, as it produced the highest tuber yield). Crop coefficient was very low at the initial stage due to relatively large diffusive resistance of bare soil after planting. Thereafter crop coefficient increased as the

Table (19):- Crop cofficient (K_c) of potato during different growth stages in summer and fall plantations.

		Ini-tial stage 20-30 days	Crop devel-opment stage 30-40 days	Mid season stage 30-45 days	Late season stage 20-25 days	Matu-ration 5-7 days	Seaso-nal (K_c)
				Summer plantation			
*	Season I	5.97	7.80	8.39	8.74	9.81	
	Season II	5.28	6.58	8.12	8.66	10.01	
	Mean	5.63	7.19	8.26	8.70	9.91	
**	Season I	4.15	5.52	7.70	5.40	4.00	
	Season II	3.01	4.92	7.84	5.98	4.20	
	Mean	3.58	5.22	7.77	5.69	4.10	
	K_c	0.64	0.73	0.94	0.65	0.41	0.75
				Fall plantation			
*	Season I	5.39	3.91	4.10	3.94	4.16	
	Season II	5.06	3.98	4.35	4.09	4.19	
	Mean	5.23	3.95	4.23	4.02	4.18	
**	Season I	1.30	2.77	4.81	3.46	3.30	
	Season II	1.30	2.58	5.16	3.52	3.30	
	Mean	1.30	2.68	4.99	3.49	3.30	
	K_c	0.25	0.68	1.18	0.87	0.79	0.77

* Potential ET, estimated by modified Penman methods mm/day.

** Actual ET, drived from wet treatment (0.5 bar in mm/day.

percent of crop cover increases. Such trend means that the diffusive resistance incrased as a result of the increase in leaf area through the period of crop coefficient. At mid season stage, crop coefficient reached its maximum value. Such period is considered as the peak water demand by potato plant. Such period is said to be the period of tuberization. Then, crop coefficient decreased again during late season stage. A sharp decreease in crop coefficient was observed at harvest time. It is worthy to mention that crop coefficient of potato plant was found to be 0.75 and 0.77 for summer and fall plantations respectively.

In this rspect Jensen (1968) pointed out that seasonal evapotranspiration for most common farm crops will be less than the potential because soil may be completely bare for sometime prior to planting. Leaf area is limited as the seedling emergesand develops,and the effective resistance to transpiration increases as the crop begins to mature.

Burch et al. (1978) concluded that the ratio betweeen actual to potential evapotranspiration increased from 0.2 early in the season to about 1.2 at later stages for well watered plants.

Doorenbos and Kassam (1979) showed that crop coefficient in the mid season stage ranged from 1.05 to 1.20. Irrigation scheduling should be based on avoiding water deficit during the period of stolonization, tuber initiation and yield formation. Ramadan (1979) showed that crop coefficient of potato plant gradually rises to a peak and then decreased in both plantations i.e. fall or summer seasons.

4.1.3.3. Water uptake :

Water uptake by potato plant roots from different soil depths under the various irrigation treatments is presented in Table (20) and illustrated in Figs. (1 and 2) for fall and summer plantations.The data were calculated from seasonal storage of water in the soil and differential extraction from soil depths up to 60 cm. Results clearly indicate that potato plant extracts approximately 80% of its moisture need from the upper foot. The highest moisture extraction occurred at the surface 15 cm (more than 50%) of the soil profile while less water was extracted as the soil depth increased. This pattern of results is similar in the two plantations i.e.fall and summer as well as in two seasons of study. Such pattern was found to be clear under the various irrigation treatments. The results indicate that the roots of potato plant were grown close to the soil surface.These findings may prove that potato plant is relatively sensitive to soil water deficit.

Table (20):- **Effect of soil moisture stress on water uptake % Pattern by potato from different soil depthes (cm).**

Treatments	Season 1989-90				Season 1990-91				Mean of two seasons			
	Depth cm											
	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
	Summer plantation											
Farmer practice	50.02	28.22	13.08	8.68	53.62	27.14	11.22	8.02	51.82	27.68	12.15	8.35
0.5 bar	58.34	20.86	12.81	7.99	57.08	22.79	12.00	8.13	57.71	21.83	12.41	8.06
1.0 bar	48.74	27.59	15.69	7.98	53.78	27.46	11.08	7.68	51.26	27.53	13.39	7.83
1.5 bars	53.98	26.80	11.73	7.56	52.75	29.02	8.73	9.50	53.37	27.91	10.23	8.53
50% Modified Penman	53.80	26.30	11.22	8.68	52.83	30.18	11.73	5.26	53.32	28.24	11.48	6.97
	Fall plantation											
Farmer practice	58.07	21.22	13.43	7.28	56.05	23.88	12.99	7.07	57.06	22.55	13.21	7.18
0.5 bar	56.09	22.20	13.29	8.43	55.91	23.16	13.10	7.82	56.00	22.68	13.20	8.13
1.0 bar	57.33	23.17	12.90	6.60	58.68	24.48	12.00	4.84	58.01	23.83	12.45	5.72
1.5 bars	49.63	25.48	14.26	10.63	48.86	24.88	14.99	11.27	49.25	25.18	14.63	10.95
50% Modified Penman	49.39	26.78	12.96	10.87	50.58	24.10	13.67	11.73	49.99	25.44	13.32	11.30

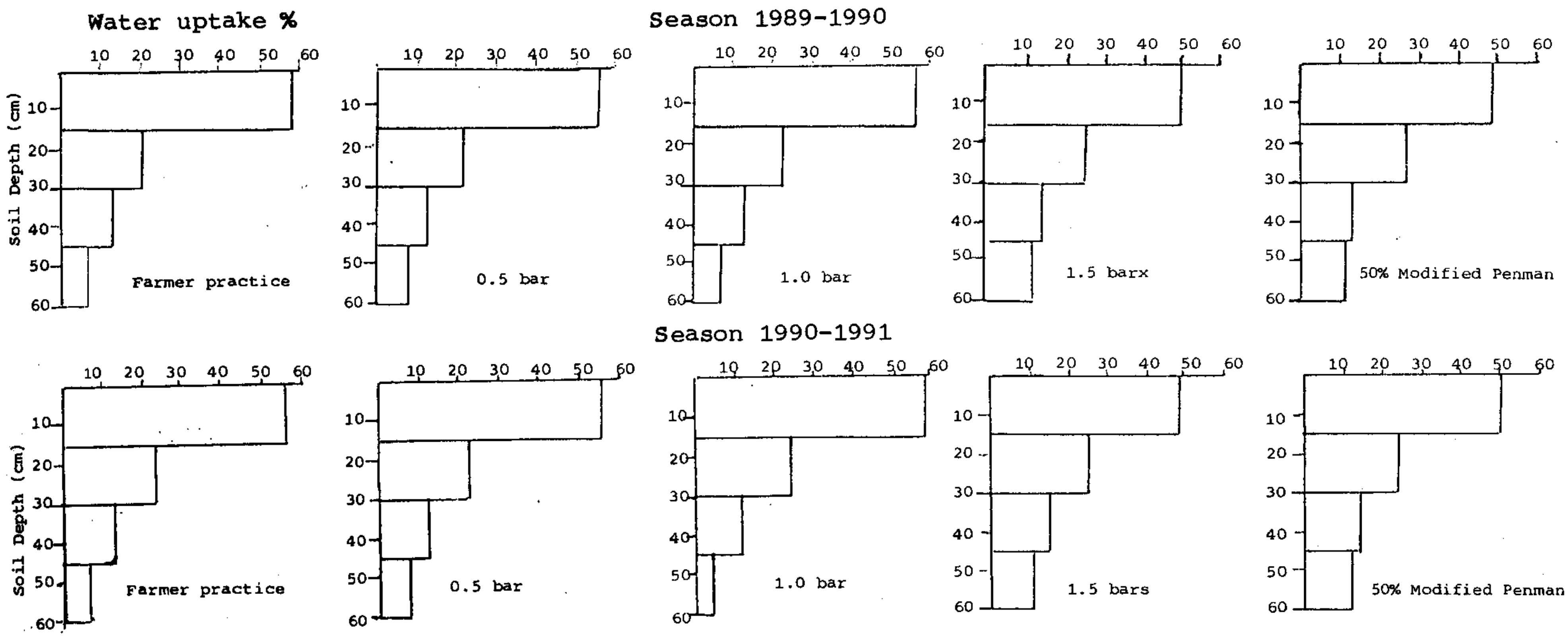


Fig. (1): Soil water uptake pattern by Potato roots for different irrigation treatments in fall plantation.

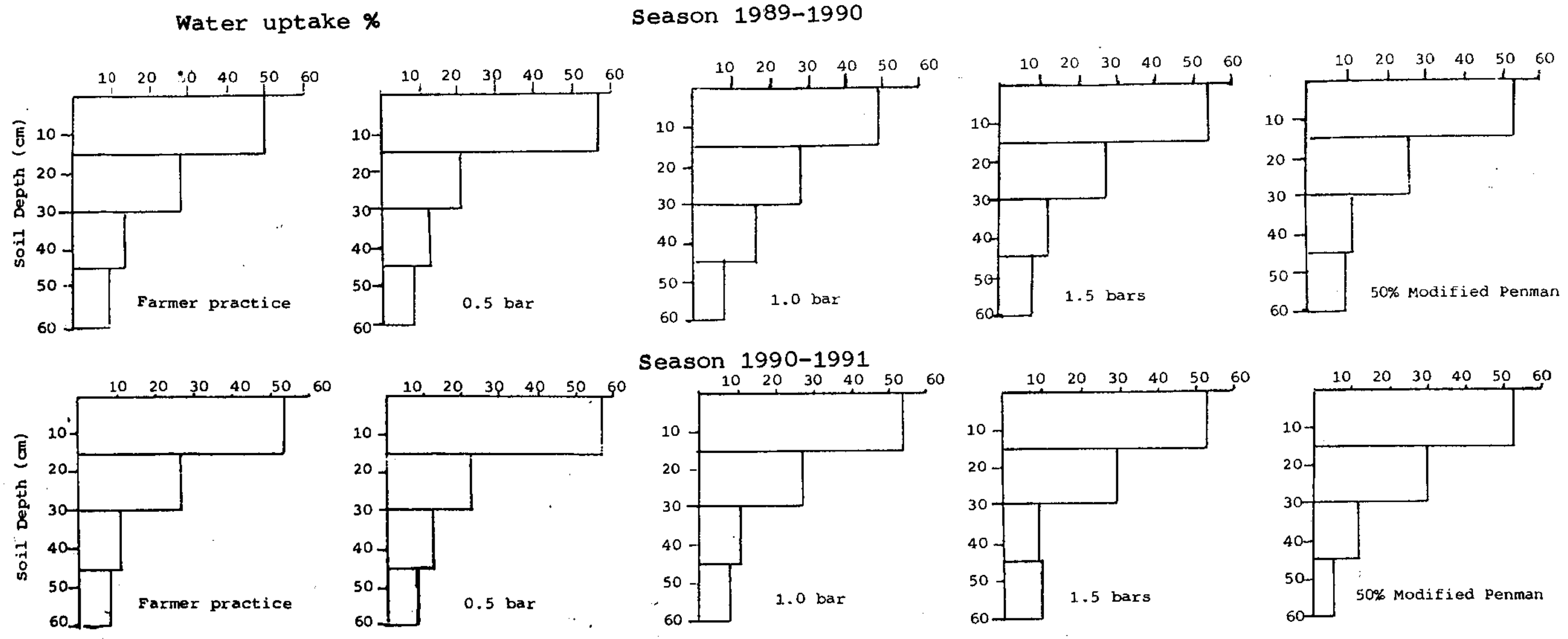


Fig. (2): Soil water uptake pattern by Potato roots for different irrigation treatments in Summer plantation.

Thus, soil should be maintained at a relatively high moisture content by frequent irrigations to avoid any soil moisture stress. In this connection, Israelsen and Hansen (1962) pointed out that in arid regions more water is extracted from the upper foot of soil, wherever it is kept more moist by frequent irrigations. Ramadan (1979) concluded that the percentage of moisture extraction in depths from 0-30 cm was 4 folds the respective one in depths from 30-60 cm in all irrigation treatments in both seasons. Doorenbos and Kassam (1979) reported that potato has a shallow root system, normally 70% of the total water uptake occurs from the upper 30 cm and 100% from the upper 40 to 60 cm soil depth. The uptake pattern will, however, also depend on the soil texture and structure.

4.1.3.4. Water use efficiency :

When irrigation water supplies are more limited and water cost increases, the water conservation objectives may shift to optimizing production per unit volume of applied water. Water use efficiency is defined as the quotient of dry matter produced per unit area over the depth of water rquired in evapotranspiration. Water use efficiency can be increasd either by increasing crop production or by decreasing losses due to evapotranspiration. Crop production can be improved by the best choice of high yielding varieties, adaptation to the particular environment as well as by improvment of water management, air and nutrient supply to the roots and of light and CO_2 to the foliage.

a) Dry matter production :

Water use efficiency expressed as kg. dry matter/ feddan/one cubic meter consumed in complete evapotranspiration for potato under different soil moisture levels is illustrated in Table (21). Rsults clearly indicate that values of water use efficiency for fall plantation are higher compared with summer plantation. These rsults are mainly due to less dry matter production in summer plantation compared with fall. Also, water consumption of fall plantation is less than that of summer.

The above mentioned factors are responsible for the lower water use efficiency values observed in summer cultivation compared with fall. It has been mentioned previously that fall plantation out-yielded summer season either in growth or final yield. It can be concluded that fall plantation is preferable from the stand point of either production or water use efficiency.

Water use efficiency was low at earlier stages of potato growth (50 days from planting) as the canopy was very small.

Table (21):- Water use efficiency by potato (kg. dry matter/feddan/m^3 ET) at different periods as affected by soil moisture stress.

Treatments	Season 1989-90			Season 1990-91			Mean of two seasons		
	Days after planting								
	50	65	80	50	65	80	50	65	80
	Summer plantation								
Farmer practice	0.65	2.23	1.89	0.86	2.22	1.83	0.76	2.23	1.86
0.5 bar	0.72	2.13	1.81	0.94	2.23	1.75	0.83	2.18	1.78
1.0 bar	0.66	2.30	1.57	0.85	2.26	1.50	0.76	2.28	1.54
1.5 bars	0.61	1.70	1.39	0.71	1.98	1.56	0.66	1.84	1.48
50% Modified Penman	0.62	1.63	1.21	0.75	2.04	1.71	0.69	1.84	1.46
	Fall plantation								
Farmer practice	3.36	5.27	3.31	0.85	6.33	3.86	2.11	5.80	3.59
0.5 bar	3.43	6.19	3.52	0.91	6.85	3.41	2.17	6.52	3.47
1.0 bar	3.23	5.30	3.47	0.78	6.38	3.78	2.01	5.84	3.63
1.5 bars	2.78	4.80	3.02	0.62	5.41	3.41	1.70	5.11	3.22
50% Modified Penman	2.50	4.73	2.74	0.55	5.25	3.44	1.53	4.99	3.09

In this period the plants are small and intercept only a small portion of radiation. However, evaporation is high from the exposed soil surface. The dry matter production in this period still at low rate. Water use efficiency reached a maximum value in the second period (65 days from planting). This increase in the values of water use efficiency can be related to higher dry matter production, leaf area increased to a maximum and the canopy covered the ground besides the tubers have been formed. Such period is considered the period of tuberization. It is well known that light interception increased with the increase in leaf area index photosynthesis and growth are proportional to the amount of light intercepted to the canopy and to the leaf area index. On the other hand evaporation from the field is not proportional to the leaf area index because it occurs from both soil and plants. Thus water utilization was at its maximum rate through such period. These results may prove the importance of providing the plant with adequate water supply through such period (65 days after planting). After that, water use efficiency values redecreased again as the plants started to mature.

In this respect, Ritchie and Burnett (1971) pointed out that water use efficiency is low at earlier stages of annual crops because growth rates are slow and large fraction of

The amount of turgidity may not directly influence the actual exchange of gases required in photosynthesis, but it will affect net photosynthesis indirectly through regulation of stomata opening. All of these reduce dry matter accumulation in plants subjected to severe moisture stress per unit of water consumed which resulted in lower water use efficiency values.

b) Tuber yield :

Table (22) represents the effect of soil moisture stress on water use efficiency expressed as kg of tuber yield/feddan/m^3 of water consumed. Results clearly indicate that water use efficiency values of fall plantation ranged from 7.40 to 10.02 kg. tubers/feddan/m^3 ET. and from 6.75 to 8.63 kg tubers/feddan/m^3 ET. in the first and second seasons respectively. As for summer plantation, the values ranged from 3.61 to 5.10 kg tubers/feddan/m^3 ET. and from 4.15 to 5.29 kg tubers/feddan/m^3 ET.in the first and second seasons respectively. The values of water use efficiency were higher for fall plantation compared with those of summer cultivation. This trend is mainly due to two factors :

(1) The higher yield production (tuber yield) in fall plantation compard with that produced in summer.

Table (22):- Water use efficiency by potato as affected by soil moisture stress.

Treatments	Summer plantation			Fall plantation		
	Season 89- 90	Season 90- 91	Mean	Season 89- 90	Season 90- 91	Mean
	Kg. Tuber yield/feddan/m^3 ET					
Farmer practice	4.12	4.90	4.51	9.81	8.37	9.90
0.5 bar	5.10	5.29	5.20	10.02	8.63	9.33
1.0 bar	4.06	4.48	4.27	10.00	8.45	9.23
1.5 bars	3.92	4.25	4.08	7.86	6.94	7.40
50% Modified Penman	3.61	4.15	3.88	7.40	6.75	7.08
	Kg.Tuber dry matter/feddan/m^3 ET					
Farmer practice	2.07	1.28	1.18	2.06	2.05	2.06
0.5 bar	1.20	1.32	1.26	2.10	2.06	2.08
1.0 bar	1.06	1.20	1.13	2.15	2.23	2.19
1.5 bars	1.06	1.19	1.13	1.64	1.83	1.74
50% Modified Penman	0.98	1.16	1.07	1.58	1.80	1.69

(2) The higher amount of water consumed by potato plants in summer in comparison to the values of evapotranspiration of fall plantation.

Those two factors are mainly responsible for decreasing the values of water use efficiency observed in summer to those obtained from fall cultivation. Water use efficiency value is a ratio between yield and water consumption. When yield production decreased and at the same time evapotranspiration rate increased lower values of water use efficiency can be observed.This trend was obtaind from summer plantation as the total tuber yield per feddan was less than fall and at the same time water consumptive use by summer plantation was higher than fall season. It can be mentioned that tuber yield is controlled by many factors among them the relation between photosynthetic activity, plant growth behaviour, translocation and accumulation of organic and inorganic compounds in tubers. These factors affect the initiation and development of tubers and controlled by the prevailing environmental conditions as daylight period, temperature, relative humidity ... etc. Such factors affect tuberization in potato plant. The short day light period (as in fall season) encourage the initiation and development of tubers than in summer season.

The stolon is directed into the soil to form tuber under ground more in fall season than in summer season. Another factors affecting tuberization of potato plant is the relationship between the reserve food which is translocated to either tuber bulking or to the developing green shoot system. During summer season, the higher absorption of water and nutrients stimulate relatively more green shoot development while the reverse is true during fall season. The relationship between the formation of carbohydrate fractions and their convertion is one of the most important factors affecting the initiation and development of tubers. The respiration rate and the balance between carbohydrate fractions is one of the most important factors affecting the tuberization i.e. the balance between sugars and the translocated material seemed to be higher in fall than in summer.

Regarding the effect of water deficit on water use efficiency by potato expressed as kg. tubers/feddan/m^3 ET. results clearly indicate that soil moisture levels induced a great response on water use efficiency values scored from the wet treatment (irrigated at 0.5 bar) in the two plantations. However, increasing soil moisture stress did result in decreasing water use efficiency values by potato plant. This trend was found to be clear in the two plantations i.e. fall or summer. However, in fall plantation, the values of water use efficiency gained from moderate soil moisture stress i.e. irrigated at 1.0 bar or farmer practice: are similar to those obtained from the wet treatment (0.5 bar). The lower water use efficiency values in fall plantation was attained from severe soil moisture stress treatments or those plots irrigated at 1.5 bars or 50% modified Penman. These results indicate that the relative decrease in potato tuber yield by moderate soil moisture stress was similar to the decrease in seasonal water consum-ption.

Moreover, increasing soil moisture stress prior irrigation more than 1.0 bar (1.5 bars or 50% modified Penman) did result in a sharp decrease in tuber yield more than the reduction in seasonal evapotranspiration which resulted in a lower water use efficiency values under such condition. As for summer plantation, results of Table (22) indicate that water deficit affected greatly the values of water use efficiency. Increasing soil moisture stress did result in decreasing the values of water use efficiency.

Such pattern of finding may prove the importance of soil moisture for higher yield production of potato tubers therby more efficient use of water. This trend seemed to be obvious in summer plantation more than fall cultivation. Thus,maintaining soil moisture at a high level not only increase tuber production but also allows the potato plant to use water more efficiently. In other words, increasing water deficit did result in decreasing crop yield and at the same time affects greatly water utilization.

The previous results may lead to the conclusion that potato plant is more sensitive to water deficit and that is more pronounced in summer plantation than fall one.

In this respect Doorenbos and Kassam (1979) concluded that potato is relatively sensitive to soil water deficit. The soil should be maintained at a relatively high moisture content. The total available soil water should not be depleted by more than 30%.

4.1.4. Chemical composition :

4.1.4.1. Mineral composition :

Results of nitrogen, phosphorus and potassium concentration expressed as mg/g, dry matter in leaves, stems and tubers of potato plant during different periods of growth as affected by soil moisture stress are recorded in Tables (23, 24 and 25).

a) Nitrogen :

Nitrogen concentration of leaves and stems increased gradually from the first sample up to the second period (65 days after planting), then slightly decreased when plants aged 80 days.

The increase in nitrogen content observed in the second sample can be related to more nitrogen absorption through this period. However, the decrease in nitrogen after that can be related to the translocation of nitrogenous compounds to the storage organ i.e. tubers as well as to the growth of plants. As for nitrogen concentration of tubers, results showed that it decreased by time from the first sample up to the last one. Such decrease is mainly due to the accumulation of carbohydrates in tubers more than other nitrogenous compounds which resulted in reducing nitrogen concentration. It is worthy to mention that leaves have higher nitrogen content

Table (23):- **Effect of soil moisture stress on nitrogen concentration in leaves, stems and tubers at different periods of potato growth (mg/g dry matter).**

Treatments	Leaves			Stems			Tubers		
	Days after planting								
	50	65	80	50	65	80	50	65	80
	Summer plantation								
Farmer practice	22.5	35.0	30.0	12.0	15.0	13.0	12.5	12.0	10.0
0.5 bar	22.5	35.0	35.0	13.0	18.5	15.0	14.0	12.5	10.0
1.0 bar	21.0	32.5	30.0	11.0	15.0	13.0	12.5	10.0	10.0
1.5 bars	18.5	28.0	25.0	11.0	14.5	12.5	11.0	8.0	6.5
50% Modified Penman	15.0	25.0	20.0	10.5	12.5	12.0	10.0	7.5	6.0
	Fall plantation								
Farmer practice	37.5	47.5	45.0	20.0	26.5	23.5	-	21.0	16.0
0.5 bar	38.0	52.5	46.0	21.0	32.0	26.0	-	24.0	17.5
1.0 bar	35.5	46.9	46.0	17.5	26.0	20.0	-	20.0	15.3
1.5 bars	35.0	45.0	38.5	16.0	25.0	18.5	-	19.9	11.1
50% Modified Penman	32.5	45.0	37.9	15.0	19.5	17.5	-	16.8	10.0

Table (24):- Effect of soil moisture stress on phosphorus concentration in leaves, stems and tubers at different periods of potato growth. (mg/g dry matter).

Treatments	Leaves			Stems			Tubers		
	Days after planting								
	50	65	80	50	65	80	50	65	80
	Summer plantation								
Farmer practice	1.5	2.8	1.5	1.4	3.0	1.7	1.2	1.6	2.0
0.5 bar	1.7	3.8	1.7	1.5	3.0	1.8	1.4	1.7	2.6
1.0 bar	1.4	3.0	1.5	1.4	2.8	1.7	1.2	1.5	1.9
1.5 bars	1.2	2.7	1.4	1.3	2.0	1.6	1.2	1.4	1.7
50% Modified Penman	1.2	2.6	1.4	1.3	1.9	1.5	1.0	1.4	1.4
	Fall plantation								
Farmer practice	1.2	3.5	2.4	1.5	2.8	1.6	-	1.7	2.3
0.5 bar	1.2	3.7	2.4	1.6	2.8	1.7	-	1.7	2.6
1.0 bar	1.2	3.4	2.4	1.5	2.7	1.5	-	1.7	2.5
1.5 bars	1.2	2.3	2.2	1.4	2.7	1.5	-	1.4	2.0
50% Modified Penman	0.8	2.2	2.2	1.5	2.7	1.5	-	1.2	2.0

Table (25):- **Effect of soil moisture stress on potassium concentration in leaves, stems and tubers at different periods of potato growth (mg/g dry matter).**

Treatments	Leaves			Stems			Tubers		
	Days after planting								
	50	65	80	50	65	80	50	65	80
	Summer plantation								
Farmer practice	52.5	48.8	33.8	58.1	87.5	65.0	30.6	31.3	24.0
0.5 bar	51.3	50.0	38.8	56.9	90.0	83.8	26.3	31.3	27.5
1.0 bar	52.5	48.8	36.3	59.0	75.0	66.3	26.3	31.3	25.0
1.5 bars	45.0	43.6	32.5	62.5	76.3	65.0	20.6	25.0	23.8
50% Modified Penman	46.3	43.8	31.3	75.0	87.5	68.8	20.6	28.8	23.0
	Fall plantation								
Farmer practice	51.3	46.3	32.5	70.0	82.5	81.3	-	36.3	28.8
0.5 bar	53.8	43.8	35.0	76.3	98.8	68.1	-	27.5	27.5
1.0 bar	48.8	45.0	31.3	81.9	88.8	86.3	-	28.1	27.5
1.5 bars	43.6	41.3	36.3	87.5	105.0	93.8	-	32.5	21.9
50% Modified Penman	43.8	42.5	30.0	79.4	99.4	96.0	-	31.9	23.8

than both stems or tubers. This pattern may be due to the development of new leaves. Also, nitrogen concentration of different potato plant organs is higher in fall plantation compared with summer one. This can be ascribed to better growth of potato in fall plantation rather than summer one which may explain the higher production of tubers in fall than summer. Halbrooks and Wilcox (1980) in Tomato plant pointed out that nitrogen concentration was higher in leaf tissue than in fruit or branch tissue. Branch and leaf nitrogen slightly decreased as the season progressed. Nitrogen accumulation by the whole plant increased sharply at 50 days due to increased branch and leaf development. After 70 days the increase in nitrogen was primarily in the fruit. Regarding the effect of water deficit on nitrogen concentration of potato plant, results showed that nitrogen content was decreased by increasing soil moisture stress. This trend was found to be true in all plant parts i.e. leaves, stems or tubers and much more in leaves than other organs as well as in severe water stress treatments than medium levels. Such results may prove that prolonged irrigation intervals or severe water deficit did result in decreasing nitrogen absorption. In this connection, Loomis and Haddock (1967) pointed out that soil water potential may influence availability and uptake of mineral nutrients as well as their accumulation within the plant. Low soil water potential may reduce total uptake of nitrogen, while plant nutrient status may be either lowered or improved as evidenced by changes in the concentration of NO_3-N in petiols or of total or soluble N in various tissues.

b) Phosphorus :

Phosphorus concentration expressed as mg/g. dry matter of potato leaves, stems and tubers during its growth cycle under the various irrigation treatments is presented in Table (24). Data showed a trend similar to that observed with nitrogen specially for leaves and stems. Phosphorus concentration increaed to reach a peak at the second sample then decreased after that. This decrease was observed in leaves and stems while tubers showed a contenious increase till the last sampling date (80 days after planting). It can be mentioned that leaves process a higher phosphorus concentration than either stems or tubers in all sampling periods.Also, the differences between the two plantations i.e. fall or summer with respect to phosphorus are very slight.

As for the effect of soil moisture stress on phosphorus concentration, results showed a reduction in P content by water deficit. Such reduction was found to be very clear under severe water stress (1.5 bars or 50% modified Penman) rather than under moderate soil moisture levels.These results are in line with those reported by Haddock (1952) who concluded that the availability of phosphorus markedly reduced at low water potential leading to low concentration in the plant.

c) Potassium :

Potato plant consumed more potassium than any other nutrients. Such element is very important in the synthesis of carbohydrate, however, does not form any organic compounds in plant. This made the element be freely translocated through the plant organs (Luxury consumption). Results of potassium concentration expressed as mg/g, dry matter during the growth cycle of potato plant are presented in Table (25).

Potassium concentration in leaves seemed to decrease gradually by time from planting up to the last sample (80 days). The reverse trend was found to be true with stems. This means that(K)in stems increased by advancing age. Such pattern can be partially explained on the translocation of this element from leaves to other plant organs.

As for the concentration of(K)in tubers, results showed that it decreased by advancing age or by the development of tubers. This pattern can be related to the dilusion effect besides that this element does not form any organic compound and translocatd freely with the plant. It is worthy to mention that no clear differences between the two plantations with respect to potassium concentration. In this connection, Halbrooks and Wilcox (1980) showed that (K) concentration of the vegetative portions of the plant was higher in branch than in leaf tissue. Potassium concentration, generally, decreased as the season progressed.

As for the effect of soil moisture stress on potassium concentration, results showed that it decreased as soil moisture stress increased in leaves only. However, the reverse trend was found to be clear in stems or tubers. In other words, (K) concentration seemed to be increased by water deficit.

4.1.4.2. Carbohydrate contents :

Data of carbohydrate contents in leaves, stems and tubers during different periods of potato growth estimated as mg. glucose/g dry matter are presented in Tables (26 & 27).

a) Total sugars :

Results of Table (26) showed the content of total sugars in leaves, stems and tubers at different periods of potato growth. A gradual increase in total sugars was observed from the first period (50 days) up to the second stage (65 days

Table (26):- **Effect** of soil moisture stress on the concentration of total sugars (mg./glucose/g. dry matter) of leaves, stems and tubers at different periods of potato growth.

Treatments	Leaves			Stems			Tubers		
	Days after planting								
	50	65	80	50	65	80	50	65	80
				Summer plantation					
Farmer practice	14.0	27.5	15.0	1.3	5.5	2.7	53.5	30.0	19.9
0.5 bar	14.5	29.5	15.6	1.3	6.5	3.0	55.5	37.7	25.0
1.0 bar	12.5	27.3	14.0	1.1	5.3	2.3	53.5	29.5	20.2
1.5 bars	10.3	26.5	12.5	1.0	5.1	1.7	47.7	25.0	17.0
50% Modified Penman	9.7	25.0	12.3	1.0	5.0	1.5	45.0	24.0	13.2
				Fall plantation					
Farmer practice	15.5	34.0	28.0	1.9	2.8	2.4	-	38.0	21.0
0.5 bar	17.5	38.5	29.5	2.3	4.5	3.4	-	55.5	35.0
1.0 bar	14.5	30.0	25.5	1.7	2.8	2.5	-	36.0	21.0
1.5 bars	12.5	20.0	19.7	1.3	2.5	2.2	-	30.0	16.5
50% Modified Penman	12.3	17.3	16.5	1.3	2.0	1.9	-	27.5	12.5

Table (27):- Effect of soil moisture stress on the concentration of total carbohydrate (mg.glucose/g. dry matter) of leaves, stems and tubers at different periods of potato growth.

Treatments	Leaves			Stems			Tubers		
	Days after planting								
	50	65	80	50	65	80	50	65	80
				Summer plantation					
Farmer practice	32.9	54.0	42.3	12.2	16.7	14.5	275.0	400.0	550.0
0.5 bar	34.5	58.0	45.0	13.0	19.0	15.0	330.0	470.0	672.5
1.0 bar	30.0	55.0	41.9	12.0	15.0	15.0	255.9	409.8	588.0
1.5 bars	29.5	38.5	32.3	11.7	14.7	13.9	250.0	315.0	485.0
50% Modified Penman	29.0	36.3	33.0	11.2	14.0	13.0	210.0	312.5	500.0
				Fall plantation					
Farmer practice	29.5	46.0	44.0	16.5	19.0	18.0	-	532.5	715.0
0.5 bar	30.0	49.5	48.0	19.0	19.5	19.0	-	587.0	755.0
1.0 bar	26.5	43.1	42.3	16.2	18.7	17.0	-	510.0	725.0
1.5 bars	22.3	35.0	31.3	14.7	17.5	16.5	-	490.0	630.0
50% Modified Penman	20.0	32.3	30.3	10.2	16.5	15.2	-	435.0	625.0

from planting). Such increase was found to be clear in leaves and stems only. However, the tubers sugar content decreased gradually from the first sample up to the last one. This reduction in tuber sugar content is mainly due to the changes of soluble sugars to polysaccarides After the second sampling period, total sugar content of leaves an d stems were decreased. Such decrease was found to be more clear in leaves than stems specially in summer plantation compared with fall. It is worthy to mention that sugar content of potato plant was higher in fall plantation than summer, with respect to leaves or stems.

This pattern can be attributed to the early formation of tubers in summer (through the 50 days after planting), compared with fall. The formation of tubers requires more carbohydrate which resulted in a quite reduction of total sugar content of leaves and stems in summer plantation due to the translocation of such relatd compounds to tubers.

Regarding the effect of water deficit on total sugars of potato plant, data of Table (26) showed that soil moisture stress decreased the accumulation of sugars in different plant parts i.e. leaves, stems and tubers. This trend was found to be obvious during the growth cycle of potato plant. In other words, total sugars seemed to be lower in plants imposed to drought conditions. The sharp reduction in total sugar content was observed under treatments irrigated at 1.5 bars or 50% modified Penman. In this respect El-Ashker (1980) showed that high soil moisture content increased the concentration of all carbohydrate fractions in all bean plant organs , except the decrease noticed in insoluble and total carbohydrates in stems.

b) Total carbohydrate :

Data of total carbohydrate in leaves, stems and tubers of potato plant throughout its growth estimatd as mg glucos/g. dry matter are presentd in Table(27).Results showed a gradual increase in total carbohydrate from the first sample up to 65 days then slightly decreased. This pattern is true in leaves and stems only while the reverse is quite clear in tubers.

In other words, total carbohydrates (mg glucose/g. dry matter) increased up to the last sample. This trend was expectd as the tubers are the storage organ of the plant. It is worthy to mention that the amount of total carbohydrate in fall plantation was found to be higher compared with summer cultivation. This pattern is true in different part organs.

Regarding the effect of water deficit on the amount of total carbohydrate, results showed that soil moisture stress had a negative response upon the accumulation of total carbohydrates. In other words, the amount of total carbohydrate (mg glucose/g dry matter) decreased by increasing soil moisture stress. This trend was found to be clear during different sampling periods and in the two tested plantations. In this connection Kramer (1977) concluded that there is important differences among species in the effect of water stress in carbohydrate metabolism. The reaction is complicated by the fact that respiration often decreased more slowly than photosynthesis causing depletion of total reserve and changing in the proportion of various carbohydrates. Anton (1991) found that carbohydrates seemed to be lowered in plants subjected to severe soil moisture stress. The author related this trend to changes in enzyme activity as well as the reduced CO_2 intake under stress conditions due to stomatal closure.

4.1.4.3. Leaf plastid pigments :

In order to determine the effect of the different irrigation treatments on leaf plastid pigments, the average concentration values of chlorophyll a and b, total chlorophyll (a + b) and carotene were estimated in terms of mg/g fresh weight. In addition, relative proportion quantities between the different examined chloroplast pigment fractions were also recorded in Table (28).Chl.a/b represent the ratio between chlorophyll a & b and (a+b)/c represent the ratio between the green and yellow pigments. Results indicate that different chloroplast pigments increased with advancing age. However, the rate of increase in the plastid pigments was not similar in the different fractions as the ratio of (a+b)/c was greatly different and it is also increased gradually with advancing age. In other words, the rate of increase in chlorophyll exceeds the rate of carotenoides increasing rate. This fact seemed to affect the rate of CO_2 assemilation and finally plant growth and its productivity. As a general, chlorophyll (a+b) concentration is less under summer plantation compared with fall.

However, carotenoides is higher under summer than fall season. Therefore, the ratio between chlorophyll (a+b) and carotenoides (c) was less in summer plantation than that observed in fall. The values of this ratio indicate the higher proportion of carotenoides under summer plantation than fall one. The higher proportion of carotenoides is to protect chlorophyll from photooxidation during summer distinguished by higher photodensity.

Soil moisture stress affected the concentration of chloroplast pigments. Chlorophyll a & b was found to be

Table (28):- Effect of soil moisture stress on the change of different pigment fractions during different periods of potato leaves mg/g fresh weight.

Treatments	50 Days after planting						65 Days after planting						80 Days after planting					
	a	b	c	(a+b)	a/b	(a+b)/c	a	b	c	(a+b)	a/b	(a+b)/c	a	b	c	(a+b)	a/b	(a+b)/c
Summer plantation																		
Farmer practice	0.99	0.79	0.37	1.78	1.25	4.81	0.93	1.10	0.42	2.03	0.85	4.83	0.84	0.94	0.36	1.78	0.89	4.94
0.5 bar	1.03	0.82	0.38	1.85	1.26	4.87	0.98	1.17	0.43	2.15	0.84	5.00	0.88	0.99	0.35	1.78	0.89	5.34
1.0 bar	0.98	0.77	0.36	1.66	1.27	4.61	0.90	1.11	0.42	2.01	0.81	4.79	0.80	0.93	0.36	1.73	0.86	4.81
1.5 bars	0.85	0.69	0.44	1.54	1.23	3.50	0.86	0.98	0.50	1.84	0.88	3.68	0.64	0.73	0.37	1.37	0.88	3.70
50% Modified Penman	0.78	0.62	0.44	1.40	1.26	3.18	0.85	0.93	0.54	1.78	0.91	3.29	0.60	0.71	0.38	1.31	0.85	3.44
Fall plantation																		
Farmer practice	0.94	0.86	0.34	1.80	1.09	5.29	1.12	1.32	0.45	2.44	0.85	5.42	1.14	1.27	0.36	2.41	0.90	6.69
0.5 bar	0.99	0.89	0.32	1.88	1.11	5.88	1.26	1.41	0.41	2.67	0.89	6.51	1.17	1.29	0.34	2.46	0.91	7.24
1.0 bar	0.90	0.83	0.34	1.73	1.08	5.09	1.10	1.30	0.46	2.40	0.85	5.22	1.12	1.22	0.38	2.34	0.92	6.16
1.5 bars	0.87	0.81	0.38	1.68	1.07	4.42	0.95	1.17	0.46	2.12	0.81	4.60	0.96	1.04	0.43	2.00	0.92	4.65
50% Modified Penman	0.84	0.77	0.39	1.61	1.09	4.13	0.90	1.15	0.47	2.05	0.78	4.36	0.92	1.00	0.40	1.92	0.92	4.80

a = Chlorophyll (a)
b = Chlorophyll (b)
c = Carotene.

higher under wet conditions and decreased by increasing soil moisture stress. The reverse trend was found with yellow pigments i.e. carotenoides. Also, the ratio between a/b seemed to be similar under various irrigation treatments which indicates that any decrease in chlorophyll (a) by water deficit is accompaned by a similar decrease in chlorophyll (b). However, the ratio (a+b)/c was decreased by water deficit. In this respect Sarag, (1983) concluded that total chlorophyll and carotene in tomato were decreased with water stress. A significant negative correlation was detected between chlorophyll content of plant leaves and their water saturation deficit.

PART II

EFFECT OF SOME GROWTH REGULATORS

4.2.1. POTATO GROWTH :

4.2.1.1. Plant height:

Plant height of potato plant at different periods of growth in summer and fall plantations is presented in Table (29). Results showed that plant height increased by advancing age. Also, the length of the plant was found to be higher in summer than fall season. Such findings are mainly due to climatic factors. Regarding the effect of GA_3 or CCC on plant height, data indicate that both substances affect the height of potato plant significantly. This trend was found to be true in the three tested periods. The application of GA_3 either at 100 or 200 ppm stimilated the plant height. On the other hand, the use of CCC depressed significantly the height of the plant compared with the control or those sprayed with GA_3. The previous results can be ascribed to the stimulative effect of the promoting substance (GA_3) on the growth of plants. However, the depressive effect of CCC may be due to its retarding effect of such material on the growth of potato plant. The stimulative effect of GA_3 can be discussed on the bases that GA_3 or anti-Gibberelline (CCC) affect either cell division and or its elongation(Jackson and Edda, 1962).

Table (29):- Effect of growth regulators on plant height (cm) of potato at various stages of growth.

Treatments	Conc. ppm	Season 1989-90			Season 1990-91			Mean of two seasons			Relative increase %		
		Days after planting											
		50	65	80	50	65	80	50	65	80	50	65	80
Summer plantation													
Control	0	41.0	66.0	86.0	43.3	61.3	84.6	42.2	63.7	85.3	49	75	100
GA_3	100	46.3	76.0	89.0	45.3	66.6	94.0	45.8	71.3	91.5	50	78	100
	200	46.3	77.6	93.0	48.0	70.0	99.0	47.2	73.8	96.0	49	77	100
	$\bar{x}$	46.3	76.8	91.0	46.7	68.3	96.5	46.5	72.6	93.8	50	77	100
CCC	1000	36.0	62.0	73.3	39.6	58.0	76.6	37.8	60.0	75.0	50	80	100
	2000	33.0	54.3	68.3	34.3	54.0	72.0	33.7	54.2	70.2	48	77	100
	$\bar{x}$	34.5	58.2	70.8	37.0	56.0	74.3	35.8	57.1	72.5	49	79	100
$\bar{x}$		40.52	67.2	81.9	42.1	62.0	85.2	41.3	64.6	83.6	49	77	100
LSD 5%		2.1	1.9	4.0	4.3	6.9	4.4	2.0	2.9	2.7			
Fall plantation													
Control	0	30.2	57.3	66.3	34.6	66.6	88.5	32.4	62.0	77.4	42	80	100
GA_3	100	35.5	65.3	75.6	42.3	82.0	92.2	38.9	73.7	83.9	46	88	100
	200	37.1	63.0	77.8	46.0	81.3	92.3	41.6	72.2	85.1	49	85	100
	$\bar{x}$	36.3	64.2	76.7	44.2	81.7	92.3	40.3	73.0	84.5	48	86	100
CCC	1000	26.0	52.0	61.8	31.0	62.5	82.0	28.5	57.3	71.9	40	80	100
	2000	26.6	51.0	60.8	30.0	63.5	86.5	28.3	57.3	73.7	38	78	100
	$\bar{x}$	26.3	51.5	61.3	30.5	63.0	84.3	28.4	57.3	72.8	39	79	100
$\bar{x}$		31.1	57.7	68.5	36.8	71.2	88.3	33.9	64.5	78.4	43	82	100
LSD 5%		5.0	7.5	11.6	4.5	5.3	12.0	3.3	4.2	7.7			

In addition, the functional role of both growth regulators is directed on stems elongation which associated with endogenous changes leading to a visible changes in whole plant growth behaviour, which is controlled by the used rate of the tested substances. Also, the prevailing environmental conditions prior and after treatments affect to a great extent the used substances.

Shadeque and Pandita (1982) reported that height of potato plant decreased by the application of CCC and this decrease increased by the concentration of CCC. The plant response to the rate of the used growth substances was controlled by the environmental conditions as it was gained some changes in the results with respect to the season of plantation i.e. summer or fall.

4.2.1.2. Number of Branches :

Number of branches for potato plant during its growth cycle is recorded in Table (30). Data showed that number of branches/plant was increased as the plant developed to reach a maximum when plants aged 65 days from planting. Growth substances affect significantly the number of branching by potato plant. Such effect either increase or decrease depends upon the type of the used substance and its concentration. The use of GA_3 at both rates increased significantly number

Table (30):- Effect of growth regulators on number of branches of potato plant at various stages of growth.

Treatments	Conc. (ppm)	Season 1989-90			Season 1990-91			Mean of two seasons			Relative increase %		
		Days after planting											
		50	65	80	50	65	80	50	65	80	50	65	80
Summer plantation													
Control	0	3.0	3.0	3.0	2.6	3.0	3.0	2.8	3.0	3.0	93	100	100
GA_3	100	3.6	4.0	4.0	3.6	3.6	3.6	3.6	3.8	3.8	95	100	100
	200	3.6	3.6	3.6	3.3	4.0	4.0	3.5	3.8	3.8	91	100	100
	$\bar{x}$	3.6	3.8	3.8	3.5	3.8	3.8	3.6	3.8	3.8	95	100	100
CCC	1000	2.0	2.6	2.6	2.0	2.3	2.3	2.0	2.5	2.5	80	100	100
	2000	2.0	2.0	2.3	2.3	2.6	2.6	2.2	2.3	2.5	86	92	100
	$\bar{x}$	2.0	2.3	2.5	2.2	2.5	2.5	2.1	2.4	2.5	84	96	100
$\bar{X}$		2.8	3.0	3.1	2.8	3.1	3.1	2.8	3.1	3.1	90	100	100
LSD 5%		0.8	1.0	1.3	0.4	0.7	0.7	0.5	0.6	0.6			
Fall plantation													
Control	0	2.6	3.0	2.6	2.0	2.3	3.3	2.3	2.7	3.0	78	90	100
GA_3	100	3.0	4.3	4.3	2.6	3.6	3.6	2.8	4.0	4.0	71	100	100
	200	3.3	3.3	3.6	2.6	3.3	3.6	3.0	3.3	3.6	86	100	100
	$\bar{x}$	3.2	3.8	4.0	2.6	3.5	3.6	2.9	3.7	3.8	76	97	100
CCC	1000	2.3	2.6	2.6	1.6	2.0	2.3	2.0	2.3	2.5	80	92	100
	2000	2.3	2.3	2.3	2.0	2.3	3.0	2.2	2.3	2.7	81	87	100
	$\bar{x}$	2.3	2.5	2.5	1.8	2.2	2.7	2.1	2.3	2.6	81	88	100
$\bar{X}$		2.7	3.1	3.1	2.2	2.7	3.2	2.5	2.9	3.2	78	91	100
LSD 5%		N.S	N.S	1.2	N.S	1.0	1.2	N.S	N.S	0.8			

of branches/ plant over the control. This type of results can be related to the stimulative effect of such substances on plant growth and thereby on branching. It can be mentioned that there is no more increase in number of branches/plant by increasing the rate of application.

On the contrary, the application of CCC did result in a significant decrease in number of branches/plant. Such pattern of finding is mainly due to the retarding effect of CCC (anti - Gibberelline) on the growth of plants.

4.2.1.3. Leaf Area :

Leaf area/plant throughout the growth cycle of potato plant in summer and fall plantations under influence of some growth regulators is presented in Table (31).

The percentage increase in total leaf area/plant for the average of two seasons is illustrated in the same Table. Leaves are very important for its role in photosynthetic assimilation role and the loss of water through transpiration. Leaf area/plant increased by advancing age from emergence up to the last period (80 days after planting). Such pattern was found to be true in fall plantation, while in summer, a slight decrease in leaf area/plant was observed when plant aged 80 days. This might

Table (34):- Effect of some growth regulators on tubers dry matter (g./plant) of potato at different period of growth.

Treatments		Season 1989-90			Season 1990-91			Mean of two seasons			Relative increase %		
		Days after planting											
		50	65	80	50	65	80	50	65	80	50	65	80
Summer plantation													
Control	0	13.0	61.2	115.0	19.4	62.2	98.7	16.2	61.7	106.9	15	58	100
GA_3	100	12.3	36.0	65.2	15.5	54.6	82.1	13.9	45.3	73.7	19	61	100
	200	12.7	36.3	59.5	13.7	43.9	62.9	13.2	40.1	61.2	22	66	100
	$\bar{x}$	12.5	36.2	62.4	14.6	49.3	72.5	13.6	42.7	67.5	20	63	100
CCC	1000	17.8	75.1	124.2	19.9	74.6	121.2	18.9	74.9	122.8	15	61	100
	2000	15.5	74.0	122.8	19.0	77.0	122.3	17.3	75.5	122.6	14	62	100
	$\bar{x}$	16.7	74.6	123.5	19.5	75.8	121.8	18.1	75.2	122.7	15	61	100
$\bar{X}$		14.3	56.5	97.3	17.5	62.5	97.4	15.9	59.5	97.4	16	61	100
LSD 5%		N.S	1.5	1.5	1.7	2.9	4.4	N.S	1.4	1.9			
Fall plantation													
Control	0	19.8	65.4	100.9	00.0	55.1	96.6	9.9	60.3	103.8	10	58	100
GA_3	100	21.5	89.6	145.5	00.0	74.1	119.0	10.8	81.9	132.3	8	62	100
	200	18.0	75.8	134.5	00.0	78.3	123.2	9.0	77.1	128.9	7	60	100
	$\bar{x}$	19.8	82.7	140.0	00.0	76.2	121.1	9.9	79.5	130.6	8	61	100
CCC	1000	29.3	102.6	160.0	00.0	90.4	151.6	14.7	96.5	155.8	9	62	100
	2000	31.1	98.8	149.0	00.0	82.3	144.2	15.6	90.6	146.6	11	62	100
	$\bar{x}$	30.2	100.7	154.5	00.0	86.4	147.9	15.1	93.6	151.2	10	62	100
$\bar{X}$		23.9	86.4	140.0	00.0	76.0	126.9	12.0	81.2	133.5	9	61	100
LSD 5%		N.S	2.6	5.9	0.0	3.5	4.6	N.S	2.1	3.4			

a) Dry matter of leaves :

Dry matter of potato leaves in the two plantations during different periods of growth as affected by growth regulators is presented in Table (32).

Results clearly indicate that leaves dry matter increase gradually to reach a maximum when plants ages 80 days. These results are similar either in fall or sum m er plantations. Leaves dry matter/plant was higher in fall than that of summer. Such trend can be related to the environmental conditions which is more suitable for potato plant in fall rather than summer.

Regarding the effect of GA_3 on dry matter accumulation in leaves, data of Table (32) indicate that the dry matter production was enhanced by the two rates of GA_3. This increase in dry matter accumulation was enhanced by increase in rate of GA_3 i.e. from 100 to 200 ppm.

Also, the increase in leaves dry matter through different growth periods was found to be significant compared with the corresponding values of the control. It can be concluded that GA_3 had a stimulative effect on the accumulation of dry matter of potato leaves and that was found to be true in both plantations.As for the growth retardant CCC, results indicate that it had a depressive effect on the accumulation of dry matter of potato leaves. Such reduction was found to be significant in both plantations as well as in the three tested period of growth. This type of finding can be related to the retarding effect of such chemical on the growth of treated plants thereby dry matter of leaves.

The previous results may be interpreted on the assumption that growth retardants such as CCC prevent GA_3 synthesis and thus retard the growth of higher plants and reduced shoot growth.

b) Stems dry matter :

Stems dry matter of potato plant under the various concentrations of GA_3 or CCC during different periods of growth in the two plantations is presented in Table (33). Results showed a similar trend to that observed with leaves. Stems dry matter increased by time from planting up to the last sample (80 days). GA_3 increased the accumulation of dry matter in stems and such increase was found to be significant over the control or these plants treated with CCC. Such increase was enhanced by the application rate. on the contrary, the use of CCC retarded the growth of plants and thereby reduced the amount of dry matter accumulation in stems.The depression in dry matter accumulation was increased by the rate of CCC application. It can be mentioned that the stimulation or the retarding effect of GA_3 or CCC on stems length were associated with the same trend in stems dry matter accumulation.

c) Tubers dry matter :

Tubers dry matter of potato plant throughout the growth cycle of the plant as affected by growth regulators in fall and summer plantations is recorded in Table (34).

Results clearly indicate that tuber dry matter increased gradually to the end of the growth season. This is mainly due to the formation of new tubers as well as to the accumulation of organic compounds in tubers. Tuber is the storage organ of the plant and comprise the final production which is the marketable yield. It can be mention that tubers dry matter expressed as g./plant in fall plantation was found to be more than the corresponding values obtained from summer plantation. Such results may prove that fall plantation is better for the production of tubers than summer. This trend might be due to climatic conditions which is more suitable for tuber production in fall than summer.

With regard to the effect of growth substances on dry matter of tubers, results showed complete changes to that observed with dry matter of either leaves or stems.The use of GA_3 enhanced the accumulation of dry matter in aeril parts, while a reverse trend was observed with tubers. Tubers dry matter was decreased by the application of GA_3 at both used rates in the different growth stages. This trend was found to be true in summer plantation. However, the reverse pattern was observed with fall plantation. In other words, GA_3 enhanced the accumulation of dry matter of tubers in all tested periods for fall plantation over the control. Thus, it can be concluded that GA_3 application affects the assimilated rate of organic matter and/or the translocation of synthesised compounds to the storage organ. Also, the environmental factors specially climate affected greatly such accumulation as observed in the variations between the two plantation i.e. fall and summer. In summer, the plant directed some of its effort to the production of flowers (under the effect of GA_3) which affect greatly the accumulation of dry matter in tubers. On the contrary, the day length in fall is not so-enough for potato to bloom (as potato is classified as a long day plant), thus, the plant directed all the assimilated materials for tuber production instead of blooming. It can be concluded that the blooming of potato plant in summer may be on the account of dry matter accumulation in tubers.

It is worthy to mention that increasing the rate of GA_3 application (200 ppm) resulted in decreasing tubers dry matter in the three tested periods of growth. This pattern was found to be true in both plantations i.e. fall or summer. In this connection, Rojas et al. (1986) concluded that gibberellic acid (15%) applied to potato plant accelerated tuber sprouting and enhanced both weight and number of tubers harvested.

Concerning the role of CCC on tubers dry matter, results showed that the application of CCC increased the accumulation of tubers dry matter in all storages of potato growth . This trend was found to differ than that observed in the shoot. In other words, CCC application retards the shoot growth but enhanced the tubers dry matter. These results are similar in both plantations i.e. fall or summer. The increase in tubers dry matter following the application of CCC either in fall or summer plantation was found to be significant over the control or those plants sprayed with GA_3. It can be mention that the enhancing effect observed with the use of CCC was found to be more in fall plantation compared with summer one. It can be concluded that in plants having a storage organs like potato, when shoot growth was decreased by CCC application, a reverse pattern can be observed with the storage organ i.e. tubers. In other words, the decrease in shoot dry matter was accompanied by a similar increase in the tuberization thereby tubers dry matter. In this respect, Shadeque and Pandita (1982) concluded that CCC application increased tuber yield and the proportion of large tubers. The most effective concentration was 500 ppm at 50 days after planting.

It is worthy to mention that higher rate of CCC (2000 ppm) resulted in a slight decrease in dry matter accumulation in tubers compared with the lower used rate (1000 ppm). However, the higher rate accelerates the accumulation of dry matter in tubers compared with the untreated plants (control). In this connection, Shadeque and Pandita (1982) found that CCC at 50 or 70 days after planting decreased fresh weight of potato plant significantly with increasing the applied rate.

d) Whole plant dry matter :

Dry matter of whole potato plant during different periods of growth in fall and summer plantations as affected by various growth regulator treatments is presented in Table (35). The accumulation of dry matter in the whole potato plant increased by time up to the last sample, as the whole dry matter is the sum of different plant parts i.e. leaves, stems and tubers. Such increase was found to be similar in both plantations(fall and summer). Dry matter of whole potato

Table (35):- **Effect of some growth regulators on whole plant dry matter (g./plant) of potato at various stages of growth.**

Treatments		Season 1989-90			Season 1990-91			Mean of two seasons			Relative increase %		
		Days after planting											
		50	65	80	50	65	80	50	65	80	50	65	80
Summer plantation													
Control	0	36.6	100.0	160.8	48.0	96.0	136.9	42.3	98.0	148.9	28	66	100
GA_3	100	43.1	84.8	120.3	54.9	101.0	133.6	49.0	92.9	127.0	39	73	100
	200	43.2	87.3	115.1	57.0	96.6	123.1	50.1	92.0	119.1	42	77	100
	$\bar{x}$	43.2	86.1	117.7	56.0	98.8	128.4	50.0	92.5	123.1	41	75	100
CCC	1000	38.2	108.2	161.9	43.3	106.8	159.6	40.8	107.6	160.8	25	67	100
	2000	35.4	105.4	157.6	41.0	109.3	157.9	38.2	107.5	157.8	24	68	100
	$\bar{x}$	36.8	107.0	160.0	42.2	108.1	158.8	39.5	107.6	159.3	25	68	100
$\bar{X}$		39.3	97.2	143.1	48.8	101.9	142.2	44.1	99.6	142.7	31	70	100
LSD 5%		2.1	2.5	3.9	1.1	2.7	5.5	1.1	1.8	3.2			
Fall plantation													
Control	0	44.7	106.1	152.5	25.5	93.1	144.8	35.1	99.6	148.7	24	77	100
GA_3	100	49.0	142.3	199.4	27.8	110.3	177.3	38.4	126.3	188.4	20	67	100
	200	47.5	129.6	190.9	27.4	118.7	187.8	37.5	124.2	189.4	20	66	100
	$\bar{x}$	48.3	136.0	195.2	27.6	114.5	182.6	38.0	125.3	188.9	20	66	100
CCC	1000	52.0	138.0	196.4	24.8	125.7	197.2	38.4	131.9	196.8	20	67	100
	2000	52.9	130.8	182.7	24.9	119.2	186.9	38.9	125.0	184.8	21	68	100
	$\bar{x}$	52.5	134.4	189.6	24.9	122.5	192.1	38.7	128.5	190.8	20	67	100
$\bar{X}$		49.2	129.4	184.4	26.1	113.4	178.8	37.7	121.4	181.6	21	67	100
LSD 5%		1.3	3.1	5.4	N.S	6.3	8.8	N.S	3.1	4.6			

plant was higher in fall plantation compared with summer in most of the sampling periods.

Regarding the effect of GA_3 on dry matter of whole potato plant, results showed the same trend to that observed with tubers as it is the largest proportion of plant dry matter. The application of GA_3 in summer plantation decreased the dry matter accumulation in whole potato plant, compared either with the control or those sprayed with CCC.

This trend is mainly due to less tuber dry matter which was reflected on whole plant dry matter. A reverse trend to that was observed in fall plantation. In other words, the application of GA_3 to potato plant in fall increased the whole plant dry matter in all stages of growth. This trend can be related to the increase in tuber dry matter. It can be concluded that the role of GA_3 on the growth and dry matter accumulative in potato plant depends mostly on the climatic factor than any other ecological factor. The effect differs according to the time of plantation. In fall GA_3 enhanced the whole plant dry matter, while in summer depressed such accumulation.

As for the effect of CCC on whole plant dry matter, results showed that CCC application did result in a significant increase in whole plant dry matter over the control and GA_3. Such increase was found to be in fall rather than in summer. The increase in whole plant dry matter by CCC application can be related to higher tubers dry matter with such treatment. It is worthy to mention that the lower CCC rate seemed to be the best concentration as a slight reduction in whole plant dry matter was observed by the higher CCC level.

These results can be observed when comparing the effect of CCC concentration on whole plant dry matter.

4.2.1.5. Flowering of Potato Plant :

The time of the year at which plant bloom is largely controlled by its reaction to day length. Potato plant is a long day plant. Some early varieties bred for temperate climate require a day length of 15-17 hours. It can be mentioned that during summer plantation, GA_3 treated plants showed blooming and the plants flower (Photo. No. 2). Such blooming observed in summer plantation may be related to the effect of GA_3 on potato plant. In this period of the year the day length is not suitable for potato plant to flower under Egyptian conditions. It was proposed by many investigators that GA_3 plays an important role as a part of florigin which induces flowering of long day plants under unfavourable conditions of day length and temperature. (Devlin and Withman, 1983).

Accordingly, GA_3 application in summer plantation may induce flowering of potato plants under summer Egyption conditions. In this connection, Black and Edelman (1970) stated that auxin tends to inhibit flowering in short day plants. Gibberellins, though cause flowering when applied to long day plants, those which form rosettes in short days. Moreover, Gibberellin level in some long day plants rises in long days. Nevertheless, gibberelline cannot be the flowering hormone, particularly because it does not inducee

Photo No. (2):- Effect of GA_3 on inducing flowering of potato plant.

flowering in short day plants.

As for fall plantation, the day length is less than summer in which GA_3 effect did not cause the potato plant to flower. Therefore, the day length is very important for Gibberellin to cause the long day plants to flower. Thus GA_3 effect will not companion completely the photo-period, which is very important in the induction of floweirng of long day plants. In this respect Satjadipura (1989) found that GA_3 treatment increased the number of fruit/plant. The same author (1989) pointed out that the use of 40 ppm GA_3 increased the number of flowers and seed production of potato plant.

It is worthy to mention that CCC (a growth retardent) did not show any effect as the same observed with GA_3 either in fall or summer cultivation. The application of CCC on potato plants did not induce blooming in such long day plant as potato. Such compound is known as anti.Gibberelline which inhibits either the formation or the role of GA_3.

4.2.2. Potato Yield :

4.2.2.1. Tuber characters :

At harvest time, samples were collected from the final tuber yield and also the following measurements were taken and recorded in Table (36). Width, length and ratio between length and width, number of tubers per plant, average tuber weight per plant, dry matter percentage, specific density and total soluble solids.

a) Tuber length and width :

Data of Table (36) showed that length and width of potato tubers were affected by growth regulators significantly over the control. The length of tuber was increased either by GA_3 or CCC application. However, the increase in tuber length by the use of GA_3 was found to be more and significantly than that caused by CCC. Such findings may indicate that GA_3 application at both rates stimulate the length of potato tuber.

The contrary of the previous results were observed with tuber width. The application of GA_3 decreased significantly tuber width without any significant effect between the two used rates i.e. 100 and 200 ppm. However, the growth retardant CCC increased the width of potato tuber significantly over either the control or those plants treated

Table (36):- Effect of some growth regulators on yield characters of potato plant in summer and fall plantations.

	Treatments								
	Control	GA_3			CCC			$\bar{X}$	LSD 5%
		100	200	$\bar{x}$	1000	2000	$\bar{x}$		
					Summer plantation				
Season 1989-1990:									
Width of tuber(cm)	12.19	10.10	10.30	10.20	11.55	11.84	11.70	11.20	0.90
Length of tuber(cm)	13.80	19.49	17.10	18.30	15.99	15.10	15.55	16.30	1.30
Tuber index=length/width	1.13	1.93	1.66	1.80	1.38	1.27	1.33	1.47	0.29
Number of tuber/plant	3.33	4.33	3.00	3.67	3.66	3.33	3.50	3.53	N.S
Tuber yield/plant(kg)	0.58	0.53	0.51	0.52	0.84	0.85	0.85	0.66	0.10
Average tuber weight(kg)	0.17	0.12	0.17	0.15	0.23	0.26	0.25	0.19	0.09
Tuber dry weight %	23.30	23.99	24.01	24.00	24.18	26.80	25.49	24.46	0.34
Tuber specfic weight	1.10	1.08	1.06	1.07	1.14	1.12	1.13	1.10	N.S
Total soluble solids	6.60	6.00	5.66	5.83	6.93	6.53	6.53	6.26	N.S
Season 1990-1991:									
Width of tuber(cm)	12.40	9.93	10.01	9.97	11.50	11.63	11.57	11.09	0.80
Length of tuber(cm)	13.50	22.47	18.98	20.73	16.10	18.00	17.05	17.81	1.90
Tuber index=length/width	1.09	2.26	1.89	2.08	1.40	1.55	1.48	1.64	0.80
Number of tuber/plant	6.33	6.00	7.00	6.50	4.33	7.00	5.67	6.13	N.S
Tuber yield/plant(kg)	0.68	0.57	0.55	0.56	0.88	0.89	0.89	0.71	0.20
Average tuber weight(kg)	0.11	0.10	0.10	0.10	0.20	0.13	0.17	0.13	0.08
Tuber dry weight %	25.10	25.37	25.20	25.29	26.98	27.50	27.24	26.03	0.37
Tuber specific weight	1.08	1.06	1.06	1.06	1.13	1.15	1.14	1.10	N.S
Total soluble solids	5.70	5.80	5.60	5.70	5.70	5.70	5.70	5.70	N.S
Mean of two seasons:									
Width of tuber(cm)	12.29	10.01	10.20	10.11	11.52	11.73	11.63	11.15	0.60
Length of tuber(cm)	13.65	20.98	18.04	19.51	16.04	16.55	16.30	17.05	1.06
Tuber index=length/width	1.11	2.09	1.77	1.93	1.39	1.39	1.41	1.55	0.30
Number of tuber/plant	4.83	5.16	5.00	5.08	3.99	5.16	4.58	4.83	N.S
Tuber yield/plant(kg)	0.63	0.55	0.53	0.54	0.86	0.87	0.87	0.69	0.10
Average tuber weight(kg)	0.14	0.11	0.14	0.13	0.22	0.20	0.21	0.16	0.02
Tuber dry weight %	24.20	24.68	24.60	24.64	25.58	27.15	26.37	25.24	0.21
Tuber specific weight	1.09	1.07	1.06	1.07	1.13	1.13	1.13	1.10	N.S
Total soluble solids	6.15	5.90	5.63	5.77	6.31	5.91	6.11	5.98	N.S
					Fall plantation				
Season 1989-1990:									
Width of tuber(cm)	10.07	7.99	8.85	8.42	11.39	11.97	11.68	10.05	0.80
Length of tuber(cm)	13.15	18.90	22.30	20.60	13.88	16.00	14.94	16.85	1.70
Tuber index=length/width	1.31	2.36	2.29	2.33	1.22	1.34	1.28	1.70	0.39
Number of tuber/plant	3.30	4.33	5.00	4.67	4.33	4.00	4.17	4.19	N.S
Tuber yield/plant(kg)	0.69	0.79	0.70	0.75	1.06	1.05	1.06	0.86	0.09
Average tuber weight(kg)	0.21	0.18	0.14	0.16	0.24	0.26	0.25	0.21	0.07
Tuber dry weight %	23.01	24.11	25.53	24.82	25.10	27.40	26.25	25.03	0.30
Tuber specific weight	1.07	1.02	1.01	1.02	1.08	1.10	1.09	1.06	N.S
Total soluble solids	5.80	5.80	5.53	5.67	5.90	6.00	5.95	5.81	N.S
Season 1990-1991:									
Width of tuber(cm)	11.64	10.69	10.45	10.57	11.46	12.46	11.96	11.34	1.10
Length of tuber(cm)	14.66	21.05	20.40	20.73	15.06	17.01	16.04	17.64	1.39
Tuber index=length/width	1.26	1.97	1.95	1.96	1.31	1.36	1.34	1.57	0.40
Number of tuber/plant	5.66	6.00	4.30	5.15	5.66	6.60	6.13	5.64	N.S
Tuber yield/plant(kg)	0.75	0.91	0.79	0.85	1.13	1.11	1.12	0.94	0.10
Average tuber weight(kg)	0.13	0.15	0.18	0.17	0.20	0.17	0.20	0.19	0.09
Tuber dry weight %	24.80	26.80	26.00	26.40	28.30	26.50	27.40	26.48	0.29
Tuber specific weight	1.05	1.01	1.01	1.01	1.07	1.09	1.08	1.05	N.S
Total soluble solids	5.66	5.76	5.26	5.51	5.73	5.50	5.62	5.58	N.S
Mean of two seasons:									
Width of tuber(cm)	10.85	9.34	9.65	9.50	11.42	12.21	11.82	10.69	0.70
Length of tuber(cm)	13.90	19.97	21.35	20.66	14.47	16.50	15.49	17.24	0.90
Tuber index=length/width	1.28	2.16	2.12	2.14	1.26	1.35	1.31	1.63	0.30
Number yield/plant	4.48	5.16	4.65	4.91	4.99	5.30	5.15	4.92	N.S
Tuber yield/plant(kg)	0.72	0.85	0.75	0.80	1.09	1.08	1.09	0.90	0.05
Average tuber weight(kg)	0.17	0.17	0.16	0.17	0.22	0.22	0.22	0.19	0.05
Tuber dry weight %	23.90	25.45	25.76	25.61	26.70	26.95	26.83	25.75	0.20
Tuber specific weight	1.06	1.01	1.01	1.01	1.08	1.10	1.09	1.05	N.S
Total soluble solids	5.73	5.78	5.39	5.59	5.82	5.75	5.79	5.69	N.S

with GA_3. It can be mentioned that the increase in tuber length may be reflected on tuber width. In other words, when tuber length increased, tuber width decreased.

b) Tuber index :

The ratio between tuber length and width is called tuber index. Results of tuber index as affected by growth regulators are recorded in Table (36). Statistical analysis showed that growth substances induced a significant response on tuber index. GA_3 or CCC application increased tuber index significantly over the control. Such finding is mainly due to the effect of growth regulators on tuber length more than their effect on width which resulted in higher values of tuber index. Both substances increased tuber length compared with the control. however, GA_3 caused more increase in tuber length than CCC. This trend did result in higher tuber index of those plants treated with GA_3 than plots sprayed with CCC. Such pattern resulted in a higher values of tuber index of plants sprayed with GA_3 compared with CCC.

It can be mentioned that GA_3 increased tuber length more than width to produce longer tubers, while CCC increased both measures to produce tuber with normal shape.

c) **Number of tubers/plant :**

Number of tubers/plant as affected by growth substances is presented in Table (36). Data showed that either GA_3 or CCC did not affect number of tubers/plant and the values are about the same. These results may indicate that such character is controlled by genetics more than environmental factors.

d) **Tuber yield/plant :**

Tuber yield/plant under the various growth regulators treatments in fall and summer plantations is shown in Table (36). Statistical analysis showed that tuber yield/plant was affected significantly by both substances i.e. GA_3 or CCC. GA_3 decreased tuber yield/plant significantly compared either with the control or those treated with CCC in summer plantation at the two used rates. On the contrary of that is fall plantation. The application of GA_3 in fall did result in a significant increase in tuber yield/plant by the lower rate i.e. 100 ppm. However, the higher rate (200 ppm) showed a slight increase in tuber yield/plant compared with the control. These results can be attributed to the effect of GA_3 on potato growth thereby on tuber yield/plant.

As for the effect of CCC on tuber yield/plant, data showed that it increased significantly by over the control or those treated with GA_3 in both plantations i.e. fall or summer. The application of CCC retard shoot growth, that was reflected on tuberization which finally increased tuber yield/plant. It can be mentioned that the increase in tuber yield/plant by CCC application was found to be more in fall plantation compared with summer one.

e) Average tuber weight :

Average tuber weight under the effect of growth regulator treatments is presented in Table (36). Results indicate that growth substances had a significant response upon such character. The use of CCC in fall or summer plantation did result in a significant increase on average tuber yield compared with either the control or GA_3 treatments. However, GA_3 application did not show any obvious effect upon tuber weight and the values are very close to those obtained from control treatment. This pattern is similar in both plantations i.e. fall or summer.

f) Tuber dry matter percentage :

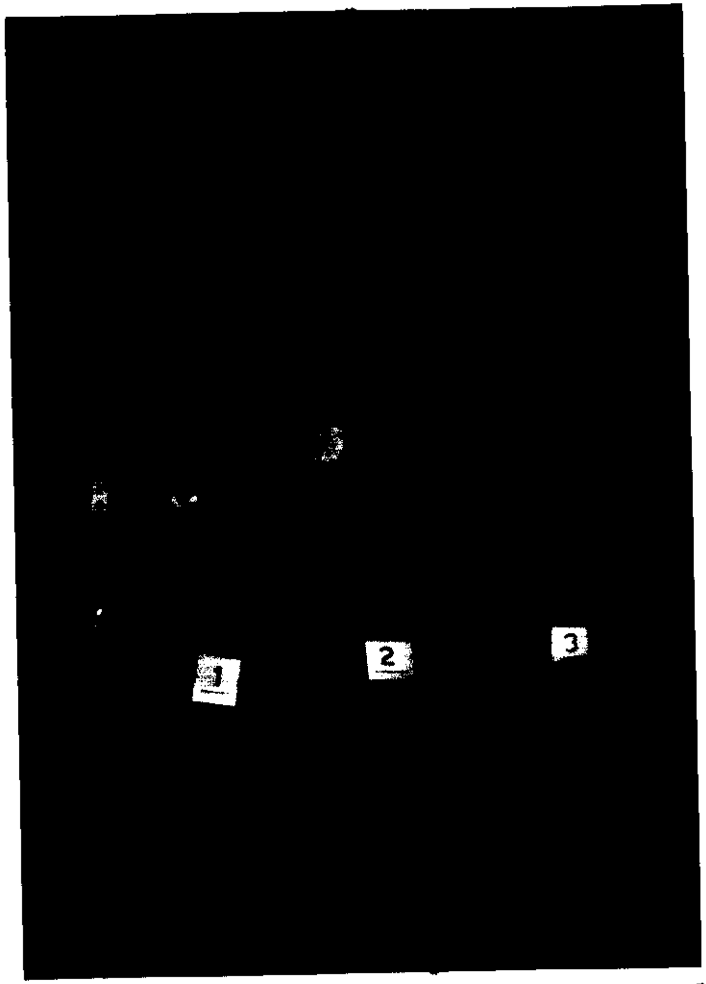
The percentage of tuber dry weight as affected by growth substances is shown in Table (36). Data indicate that tuber dry matter percentage increased by the use of CCC in both plantations. Such increase was found to be significant over the control and GA_3 treatments. However, GA_3 increased tuber dry matter percentage in fall plantation only. This increase was significant compared with the control treatment. On the other hand, GA_3 application in summer plantation failed to affect tuber dry matter percentage and the values obtained were similar to those from control treatment.

g) Tuber specific weight :

Data of specific weight for tubers showed that growth regulators had no significant response on such character. However, the values obtained from those treatments sprayed with CCC showed a slight increase in tuber specific weight specially in summer plantation. Such type of finding was found to be not clear in fall plantation. In this respect Shadeoque and Panita (1982), showed that foliar application of CCC at (50) days after planting increased specific gravity of potato tubers.

h) Total soluble solids :

Total soluble solids of potato tubers as related to different growth regulator treatments (Table36) indicate that it was not affected by such treatments. The values obtained are similar as compared with control treatment. These results are the same in both plantations i.e. fall or summer.



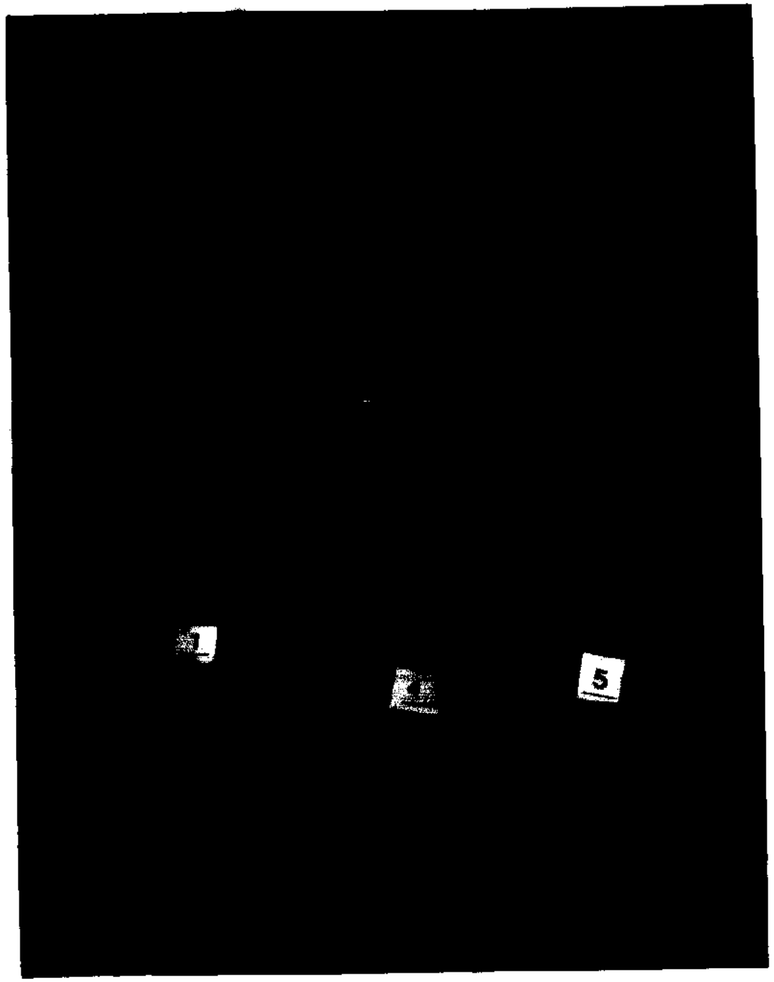


Photo (3) : Effect of growth regulators on potato shape and size as affected by different treatments.*

* 1) Control
2) CCC 1000 ppm
3) CCC 2000 ppm
4) GA_3 100 ppm
5) GA_3 200 ppm

4.2.2.2. Tuber Production :

Potato yield expressed in Tons/feddan in the two seasons as well as in the two plantations under the effect of GA_3 and CCC is presented in Table (37). Results clearly indicate that tuber production in fall plantation out-yielded the summer plantation. This trend was observed in the two seasons of study.

Regarding the effect of GA_3 on tuber production, results did not show the same trend in both plantations. In other words the foliar application of GA_3 in summer did result in a significant reduction in tuber production compared either with the control or those plants treated with CCC. Such reduction in tuber yield was decreased by increasing the rate of GA_3 application i.e. from 100 to 200 ppm. The reverse of that trend was observed when GA_3 was applied at fall plantation. The application of GA_3 at the lower rate (100 ppm) increased tuber yield expressed as ton/feddan. This increase was found to be significant over the control treatment. However, when increasing the rate of GA_3 application up to 100 ppm; potato did not show any obvious increase in tuber yield and the values are similar to the control treatment.

These results may indicate that for fall plantation, the

Table (37):- Effect of some growth regulators on tuber yield (Ton/ feddan) of potato plant.

Treatments		Summer plantation			Fall plantation		
		Season 89-90	Season 90-91	Mean	Season 89-90	Season 90-91	Mean
Control	0	9.28	10.80	10.04	12.00	11.04	11.52
GA_3	100	8.48	9.12	8.80	14.56	12.64	13.60
	200	8.08	8.72	8.40	12.64	11.20	11.92
	$\bar{x}$	8.28	8.92	8.60	13.60	11.92	12.76
CCC	1000	13.44	14.08	13.76	18.08	16.96	17.52
	2000	13.60	14.24	13.92	17.68	16.80	17.24
	$\bar{x}$	13.52	14.16	13.84	17.88	16.88	17.38
$\bar{X}$		10.58	11.39	10.99	14.99	13.73	14.36
LSD 5%		1.60	1.04	1.12	1.9	1.40	1.2

pronounced concentration was 100 ppm. More than that level, did not cause any conspicuous increase in tuber yield but may induce a slight reduction in potato production. The previous results may explain that environmental conditions affect greatly the behaviour of growth substances. The photo-period requirements of potato plant reflected its effect on tuberization which control the final yield or tuber yield. It is worthy to mention that the use of GA_3 in summer plantation induce potato plant to flower, this also, is another factor which reduce tuber production. The plant directed some of its effort for tuberization and part of it for flowering. The total assimilated materials are divided between the two directions one for tuberization and the rest for flowering. Those may be the reasons for the reduction of tuber yield observed in summer plantation when GA_3 was applied.

In this respect Bodlaender et al. (1989) concluded that GA_3 applied before the beginning of tuberization promoted stem elongation,stolon growth and slightly retarded tuber initiation. The high rate produced long curved tubers. GA_3 stimulated flowering.

El Abed (1979),in Egypt,found that GA_3 application to potato in late summer reduced yield specially at the high concentration. The same author added that GA_3 at 50 ppm was ineffective in reducing yield in late nili cultivation.

As for the effect of CCC (a growth retardant) results showed that the application of CCC increased tuber yield. Such increase was found to be significant compared with the control plots or those treated with GA_3. It can be mentioned that both rates i.e. 1000 or 2000 ppm increased tuber production over the control treatment. However, no obvious increase in tuberization (tuber production) was observed between the two levels of CCC. Thus, it can be concluded that the most pronounced concentration for CCC was 1000 ppm. Such level (1000 ppm) can be recommended for higher tuber production.

The previous results can be explained on the bases that growth retardant affects the shoot growth while enhanced tuberization. This was reflected on the final potato production or tuber yield. It is worthy to mention that the increase in tuber yield by CCC application was found to be more in fall plantation compared with summer cultivation. This,again may assure that environmental factors affect the behaviour of growth substances and their response on the treated plants. In this connection Lis (1980) concluded that application of CCC to potato accelerated tuber formation and prolonged the tuber formation period. Golovko and Tabalenkova

(1989) showed that using 0.7 % chlormequat solution, 25 days after emergence did result in increasing tuber dry weight yields by 30%.

It appears as a reasonable hypothesis to assure that hormonal regulation is involved in control of water potential and membrane permeability and thus in the control of plant water deficits. In accordance with this view, the response of plants to environmental water stress is associated in a regulatory fashion with changes in levels and activity of various hormones in the plant. Such change may provide a mechanism of adaptation of plants to varying environmental conditions.

4.2.3.1. Actual Evapotranspiration :

a) Seasonal rates :

Seasonal water consumptive use of potate plant in fall and summer plantations through the period of study as affected by growth regulators is presented in Tables (38 & 39). Seasonal water consumption varies widely between 317.5 and 371.7 mm in the first season and between 334.4 and 406.8 mm in the second season for fall plantation. As for summer plantation the values ranged from 480.6 to 589.7 mm in the first season and from 457.5 to 606.9 mm in the second season. It is clear from the previous results that there are a slight increase in seasonal water use in the second season compared with the first one. Such trend was found to be true either in fall or summer plantation. This pattern can be related to differences in climatic conditions which affect the

Table (38):- Water consumptive use (mm) by potato plant for fall plantation as affected by some growth regulators.

Treatments		Oct*	Nov. 1-15	Nov. 16-30	Dec. 1-15	Dec. 16-31	Jan. 1-15	Jan. 16-31	Feb.**	Total
					Season 1989-90					
Control	0	17.6	16.5	16.5	41.8	56.8	63.0	64.5	78.0	354.7
GA_3	100	17.6	16.5	16.5	47.3	63.9	66.0	65.9	78.0	371.7
	200	17.6	16.5	16.5	45.1	62.5	72.0	66.9	74.0	371.1
	$\bar{x}$	17.6	16.5	16.5	46.2	63.2	69.0	66.4	76.0	371.4
CCC	1000	17.6	16.5	16.5	36.3	54.3	57.0	57.2	68.0	323.4
	2000	17.6	16.5	16.5	39.6	52.4	54.0	54.9	66.0	317.5
	$\bar{x}$	17.6	16.5	16.5	37.9	53.4	55.5	56.1	67.0	320.5
$\bar{X}$		17.6	16.5	16.5	42.0	58.0	62.4	61.9	72.8	347.7
					Season 1990-91					
Control	0	30.0	18.0	20.9	61.5	66.8	57.5	59.2	51.8	365.7
GA_3	100	30.0	18.0	21.0	63.0	75.6	72.5	62.4	54.6	397.1
	200	30.0	18.0	21.2	66.0	77.6	74.0	64.0	56.0	406.8
	$\bar{x}$	30.0	18.0	21.1	64.5	76.6	73.3	63.2	55.3	402.0
CCC	1000	30.0	18.0	20.4	54.0	64.8	62.3	56.0	49.0	354.5
	2000	30.0	18.0	20.2	51.0	58.0	55.2	54.4	47.6	334.4
	$\bar{x}$	30.0	18.0	20.3	52.5	61.4	58.8	55.2	48.3	344.5
$\bar{X}$		30.0	18.0	20.7	59.1	68.6	64.3	59.2	51.8	371.7

* 16 Days (Season I)
25 Days (Season II)

** 20 Days (Season I)
14 Days (Season II)

Table (39):- Water consumptive use (mm) by potato plant for summer plantation as affected by some growth regulators.

Treatments		Feb.*	Mars		April		May		June**	Total
			3-15	16-31	1-15	16-30	1-15	16-31		
					Season 1989-1990					
Control	0	-	52.7	50.9	88.5	88.5	91.1	87.2	76.9	535.8
GA_3	100	-	52.7	51.2	93.0	96.9	106.6	99.6	85.1	585.1
	200	-	52.7	51.3	94.5	98.4	108.1	90.8	93.9	589.7
	$\bar{x}$	-	52.7	51.3	93.8	97.7	107.4	95.2	89.5	587.4
CCC	1000	-	52.7	50.3	79.5	79.5	82.1	76.3	70.4	490.8
	2000	-	52.7	50.1	76.5	79.1	82.1	75.0	65.1	480.6
	$\bar{x}$	-	52.7	50.2	78.0	79.3	82.1	75.7	67.8	485.7
$\bar{X}$		-	52.7	50.7	86.4	88.5	94.0	85.8	78.3	536.4
					Season 1990-1991					
Control	0	26.6	42.0	58.0	78.9	91.5	92.2	84.8	50.5	524.5
GA_3	100	26.6	42.0	62.4	82.2	102.8	113.3	100.8	55.9	586.0
	200	26.6	42.0	62.4	85.8	106.0	120.3	103.6	60.2	606.9
	$\bar{x}$	26.6	42.0	62.4	84.0	104.4	116.8	102.2	58.1	596.5
CCC	1000	26.6	62.0	54.7	68.1	78.6	81.0	75.6	49.5	476.1
	2000	26.6	42.0	52.1	65.7	74.2	75.7	74.4	46.8	457.5
	$\bar{x}$	26.6	42.0	53.4	66.9	76.4	78.4	75.0	48.2	466.8
$\bar{X}$		26.6	42.0	57.9	76.1	90.6	96.5	87.8	52.6	530.2

* 8 Days (Season I).

** 20 Days (Season I)
11 Days (Season II)

evaporative power of the air.

The values of seasonal water use by potato plant showed that potato plant grown in summer did consume more water than fall. This result is expected due to differences in climatic factors prevailing through the growth period of potato in the two seasons. If we consider the values of potential evapotranspiration, this can explain why summer plantation consume more water than fall growth season. The values of potential evapotranspiration in summer were higher than fall. Solar radiation and temperature in summer months are higher than winter months. In this respect, Chang(1971) showed that the rate of evapotranspiration depends on the evaporative power of the air as determined by temperature, humidity and net radiation. Doorenbos and Pruitt (1977) concluded that from year to year, the monthly values of ET. show greater variations. Daily values can vary drastically with low values on days that are rainy, humid and calm, and with high values on dry, sunny and windy days.

Regarding the effect of growth regulators on seasonal water use by potato plant, results showed a great variations on evapotranspiration. Seasonal water consumptive use by potato in fall plantation were 354.7, 371.7, and 371.1 mm respectively for treatments sprayed with 0, 100 and 200 mm

GA_3 in the first season. The corresponding values of the second season were 365.7, 397.1 and 406.8 mm for treatments in the same order. The respective values for summer plantation were 535.8, 585.1 and 589.7 mm in the first season and 524.5, 586.0, and 606.9 mm for the same treatments. The previous results indicate that GA_3 application at both rates increased seasonal water use by potato plant compared with the control. This trend was found to be true either in fall or summer plantation. Increasing the rate of GA_3 application resulted in a slight increase in seasonal evapotranspiration by potato plant in both plantations. It is intersting to mention that the increase in seasonal evapotranspiration following the application of GA_3 was found to be more in summer plantation than fall season.

The previous results can be explained on the basis that GA_3 promotesthe growth of potato plant and increas e s the transpiring surface (leaf area/plant) which was reflected on the values of seasonal water consumption. In this respect, Livne and Vaadia (1965) concluded that cytokinins and apparently also Gibberellic acid are unique among the compounds which affect stomatal opening, in that they simultaneously promote stomatal opening and other physiological processes. Kinetin enhances transpiration rate and the opening of stomata. Also, the above mentioned results are in full agreement with those found by Eweida et al. (1978), Seif El-Yazal et al. (1983), Miseha (1983), Abbas (1992) who reported a considerable increase in seasonal evapotranspiration rates by plants sprayed with 2, 4-D and GA_3.

In case of CCC, seasonal water use by potato plant in fall plantation were 354.7, 323.4 and 317.5 mm in the first season and 365.7, 354.5, and 334.4 mm in the second season respectively for treatments sprayed with 0, 1000 and 2000 ppm CCC. The corresponding values for summer plantation were 535.8, 490.8, and 480.6 mm in the first season and 524.5, 476.1, and 457.5 mm in the second season for treatments in the same order. Results showed a reverse trend to that observed with GA_3. Potato plants treated with the growth retardant CCC showed a quite decrease in seasonal evapotranspiration rates. Increasing the applied rate of CCC i.e. from 1000 to 2000 ppm did result in decreasing seasonal evapotranspiration by potato plant. It is worthy to mention that the decrease in water use by potato was found to be more obvious in summer plantation compared with fall one.

The reduction in seasonal water use by the application of CCC can be related to the retarding effect of such chemical on the growth of plants. It has been mentioned previously that the growth of potato plant was reduced and the

Table (40):- **Effect** of some growth regulators on daily evapotranspiration (mm) of potato in fall plantation.

Treatments		Oct.	Nov. 1-15	Nov. 16-30	Dec. 1-15	Dec. 16-32	Jan. 1-15	Jan. 16-31	Feb.	Mean
Season 1989-90										
Control	0	1.10	1.10	1.10	2.79	3.55	4.20	4.03	3.90	2.72
GA_3	100	1.10	1.10	1.10	3.15	3.99	4.40	4.12	3.90	2.86
	200	1.10	1.10	1.10	3.01	3.91	4.80	4.18	3.70	2.86
	$\bar{x}$	1.10	1.10	1.10	3.08	3.95	4.60	4.15	3.80	2.86
CCC	1000	1.10	1.10	1.10	2.42	3.39	3.80	3.58	3.40	2.49
	2000	1.10	1.10	1.10	2.64	3.28	3.60	3.43	3.30	2.44
	$\bar{x}$	1.10	1.10	1.10	2.53	3.34	3.70	3.51	3.35	2.46
$\bar{X}$		1.10	1.10	1.10	2.80	3.62	4.16	3.87	3.64	2.67
Season 1990-91										
Control	0	1.20	1.20	1.39	4.10	4.18	3.83	3.70	3.70	2.91
GA_3	100	1.20	1.20	1.40	4.20	4.73	4.83	3.90	3.90	3.17
	200	1.20	1.20	1.41	4.40	4.85	4.93	4.00	4.00	3.25
	$\bar{x}$	1.20	1.20	1.41	4.30	4.79	4.88	3.95	3.95	3.21
CCC	1000	1.20	1.20	1.36	3.60	4.05	4.15	3.50	3.50	2.82
	2000	1.20	1.20	1.35	3.40	3.63	3.68	3.40	3.40	2.66
	$\bar{x}$	1.20	1.20	1.36	3.50	3.84	3.92	3.45	3.45	2.74
$\bar{X}$		1.20	1.20	1.38	3.94	4.29	4.28	3.70	3.70	2.96

Table (41):- **Effect** of some growth regulators on daily evapotranspiration (mm) of potato in summer plantation.

Treatments		Feb. 21-28	Mars 3-15	Mars 16-31	April 1-15	April 16-30	May 1-15	May 15-31	June 1-15	June 16-20	Mean
					Season 1989-90						
Control	0	-	4.39	3.18	5.90	5.90	6.07	5.45	4.09	3.90	4.86
GA_3	100	-	4.39	3.20	6.20	6.46	7.11	6.23	4.53	4.30	5.30
	200	-	4.39	3.21	6.30	6.56	7.21	5.68	4.95	4.90	5.40
	$\bar{x}$	-	4.39	3.21	6.25	6.51	7.16	5.96	4.74	4.60	5.35
CCC	1000	-	4.39	3.14	5.30	5.30	5.47	4.77	3.73	3.60	4.46
	2000	-	4.39	3.13	5.10	5.27	5.47	4.69	3.46	3.30	4.35
	$\bar{x}$	-	4.39	3.14	5.20	5.29	5.47	4.73	3.60	3.45	4.41
$\bar{X}$		-	4.39	3.17	5.76	5.90	6.27	5.36	4.15	4.00	4.87
					Season 1990-91						
Control	0	3.33	2.80	3.63	5.26	6.10	6.14	5.30	4.59	-	4.64
GA_3	100	3.33	2.80	3.90	5.48	6.85	7.55	6.30	3.73	-	4.99
	200	3.33	2.80	3.90	5.72	7.07	8.02	6.48	5.47	-	5.35
	$\bar{x}$	3.33	2.80	3.90	5.60	6.96	7.79	6.39	4.60	-	5.17
CCC	1000	3.33	2.80	3.42	4.54	5.24	5.40	4.73	4.50	-	4.25
	2000	3.33	2.80	3.26	4.38	4.95	5.05	4.65	4.25	-	4.08
	$\bar{x}$	3.33	2.80	3.34	4.46	5.10	5.23	4.69	4.38	-	4.17
$\bar{X}$		3.33	2.80	3.62	5.08	6.04	6.43	5.49	4.51	-	4.66

small and intercept little of the met radiation. A gradual increase in the values of daily water use by potato plant were observed as the plants developed. These results can be attributed to the growth of plants and to the increase in percent of crop cover. Thereafter, daily rates recorded its maximum when plant aged from 70-85 days in fall and summer plantations. These results may prove that the increase in evapotranspiration is mostly related to the increase in percent cover. When plants completely shading the ground, maximum evapotranspiration attained. Also, such period is considered as the period of tuberization and the plants consume much water for the storage organs. Then, daily values of water use gradually decreased as the plants going to maturity. In this respect Gates and Hanks (1967) concluded that plant factors undoubtedly influence evapotranspiration from a crop. The greater influence among crops occur during the growth period when the crop cover is < 50% complete. During this time evapotranspiration of most irrigated crops is less than where cover is greater, because evaporation from bare soil decreases faster than transpiration by crops. It appears a little difference in evapotranspiration among many crops after cover is > 50% until maturity.

Regarding the effect of growth substances i.e. GA_3 on daily water use, results of Tables (40 & 41) showed an increase in daily evapotranspiration following the application of such chemical. This trend can be relating to the enhancing effect of GA_3 on the growth of potato plant as well as on transpiration. On the contrary, when concerning CCC treatments (a growth retardant) results showed an obvious decrease in daily evapotranspiration. Such type of results may be due to the reduced growth by CCC beside its effect on the biosynthesis of GA_3 in those plants treated with CCC. It has been mentioned previously that potato plants sprayed with CCC are shorter and less in their growth compared with either untreated or those sprayed with GA_3. In this respect, Gates and Hanks (1967) pointed out that plant height and size appears to influence evapotranspiration by greater interception of advected heat. Thus plant height would affect evapotranspiration of the taller plants were isolated in a field. Miseha (1983) and Abbas (1992) pointed out that plants sprayed with growth promoting substances increased daily evapotranspiration and that developed at later periods of growth. However, in case of growth retardants, a reduction in daily rates was gained.

4.2.3.2. Crop Coefficient (K_c) :

The percent of crop cover and any modification on the growth of plants either by promotion or retardation affects the crop coefficient. Miseha (1983) concluded that any environmental factor that affects the resistance to vapour diffusion may result in changes in crop coefficient either by increasing or decreasing such values. Changes in crop coefficient (K_c) may affect directly the evapotranspiration of a crop in concern.

The growth season of potato plant can be defined to the following stages :

1. Initial stage : early growth (20-30 days) after planting.
2. Crop development stage (30-40 days) after Initial stage
3. Mid season stage (30-45 days) after Crop development stage
4. Late season stage (20-25 days) after Mid season stage.
5. Maturation, after late season stage to maturity.

The crop coefficient of potato plant during its growth season in summer and fall plantations is presented in Table (42). The values were calculated according to the daily potential evapotranspiration estimated by Penman's method and actual water consumptive use for the control, GA_3 and CCC growth substances.

Crop coefficient was low at the initial stage due to less crop cover after planting. Then, crop coefficient increased during the crop development stage. This is mainly related to the increase in the percent of crop cover which

Table (42):- Crop coefficient (K_c) of potato during different periods of growth in summer and fall plantations as related to growth regulators.

		Initial stage 20-30 days	Crop development stage 30-40 days	Mid season stage 30-45 days	Late season stage 20-25 days	Maturation 5-7 days	Seasonal (K_c)
				Summer plantation			
*	Season I	5.97	7.80	8.39	8.74	9.81	
	Season II	5.28	6.58	8.12	8.66	10.01	
	Mean	5.63	7.19	8.26	8.70	9.91	
++	Season I	3.81	5.46	5.90	4.75	3.90	
	Season II	3.13	4.71	6.09	5.02	4.59	
	Mean	3.47	5.09	6.00	4.89	4.25	
	K_c	0.62	0.71	0.73	0.56	0.43	0.65
**	Season I	3.82	5.83	6.74	5.23	4.60	
GA_3	Season II	3.20	5.04	7.36	5.67	4.60	
	Mean	3.51	5.44	7.05	5.45	4.60	
	K_c	0.62	0.76	0.85	0.63	0.46	0.71
**	Season I	3.79	4.89	5.27	4.05	3.45	
CCC	Season II	3.07	4.08	5.15	4.57	4.38	
	Mean	3.43	4.49	5.21	4.31	3.92	
	K_c	0.61	0.62	0.63	0.50	0.40	0.58
				Fall plantation			
*	Season I	5.39	3.91	4.10	3.94	4.16	
	Season II	5.06	3.98	4.35	4.09	4.19	
	Mean	5.23	3.95	4.23	4.02	4.18	
++	Season I	1.10	2.15	4.01	3.92	3.90	
	Season II	1.20	2.23	3.97	3.70	3.70	
	Mean	1.15	2.19	3.99	3.81	3.80	
	K_c	0.22	0.55	0.94	0.95	0.91	0.67
**	Season I	1.10	2.33	4.30	3.85	3.80	
GA_3	Season II	1.20	2.30	4.73	3.95	3.95	
	Mean	1.15	2.32	4.52	3.90	3.88	
	K_c	0.22	0.59	1.07	0.97	0.93	0.72
**	Season I	1.10	2.02	3.56	3.37	3.35	
CCC	Season II	1.20	2.10	3.82	3.45	3.45	
	Mean	1.15	2.06	3.69	3.41	3.40	
	K_c	0.22	0.52	0.87	0.85	0.81	0.62

* Potential ET, estimated by modified Penman method in mm/day.
++ Control.
** Actual ET, in mm/day as the mean of two used rates.

affects the diffusive resistance owing to the increase in leaf area index. At mid season stage, crop coefficient was at a maximum which represents the peak period of water demand by potato plant. Also, such period is defined as the tuberization period. Thereafter, crop coefficient decreased at late season stage and at harvest time.

Regarding the effect of growth regulators on K_c values, results indicate that growth promoting substances (GA_3) increased such values. This increase is expected as the promoting compound affects the growth of potato plant. The transpiring surface (leaf area/plant) increased by the use of such compound which finally increased the values of K_c. On the contrary, the use of CCC a growth retardant caused a decline in the values of potato crop coefficient. The use of CCC retards the growth of potato plant thereby increased the resistance to transpiration and hence decreased the values of K_c. In this respect Abbas (1992) showed that the crop coefficient was increased by the application of GA_3. However, when a growth retardant was applied, a decrease in K_c values was observed.

4.2.3.3. Water Uptake :

Water uptake by potato plant roots from different soil moisture depths as affected by growth regulators is presented in Table (43) and illustrated in Figs. (3 & 4) for fall and summer plantation.

Results indicate that potato plant extracts about 80% of its moisture need from the first foot. However, more than 50% was extracted from the 15 cm of the soil profile. This pattern of results may indicate that potato plant is shallow rooted plant and irrigation water must be applied frequently to avoid any moisture stress. The previous results was found to be similar either in fall a summer plantation.

Regarding the role of growth regulators on water uptake by potato roots, results indicate no clear changes in the percent of soil moisture depleted from different soil depths. These results may prove that the growth substances affect greatly the shoot system, while root system remain unchanged or unaffected by such chemical.

4.2.3.4. Water Use Efficiency :

Water use efficiency is defined as the quotient of dry matter or marketable weight of a crop produced per unit area over the depth of water required in evapotranspiration to produce the crop. Water use efficiency can be increased

Table (43):- Effect of some growth regulators on water uptake % Pattern by potato from different soil depthes (cm).

Treatments		Season 1989-90				Season 1990-91				Mean of two seasons			
		Depth cm											
		0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
Summer plantation													
Control	0	49.76	28.40	13.42	8.42	54.98	25.60	11.39	8.03	52.37	27.00	12.41	8.23
GA_3	100	50.66	28.74	12.38	8.22	56.89	24.23	11.54	7.34	53.78	26.49	11.96	7.78
	200	50.37	28.63	12.84	8.16	57.77	24.11	10.80	7.32	54.07	26.37	11.82	7.74
	$\bar{x}$	50.52	28.69	12.61	8.19	57.33	24.17	11.17	7.33	53.93	26.43	11.89	7.76
CCC	1000	47.30	29.64	13.48	9.58	55.19	27.06	11.19	6.56	51.25	28.35	12.34	8.07
	2000	49.92	28.56	13.50	8.02	56.05	26.93	10.88	6.14	52.99	27.75	12.19	7.08
	$\bar{X}$	48.61	29.10	13.49	8.80	55.62	27.00	11.04	6.35	52.12	28.05	12.27	7.58
$\bar{X}$		49.60	28.79	13.12	8.48	56.18	25.59	11.16	7.08	52.89	27.19	12.14	7.78
Fall plantation													
Control	0	57.33	22.63	13.13	6.92	56.54	25.66	12.07	5.73	56.94	24.15	12.60	6.33
GA_3	100	58.92	23.37	11.48	6.22	56.97	23.85	12.34	6.84	57.95	23.61	11.91	6.53
	200	58.58	25.08	10.97	5.37	56.59	25.46	11.86	6.09	57.59	25.27	11.42	5.73
	$\bar{x}$	58.75	24.23	11.23	5.80	56.78	24.66	12.10	6.47	57.77	24.44	11.67	6.13
CCC	1000	57.57	22.88	12.97	6.58	57.18	23.62	12.43	6.77	57.38	23.25	12.70	6.68
	2000	56.88	23.01	13.46	6.65	58.80	22.41	11.65	7.14	57.84	22.71	12.56	6.90
	$\bar{x}$	57.23	22.95	13.22	6.62	57.99	23.02	12.04	6.96	57.61	22.98	12.63	6.79
$\bar{X}$		57.86	23.39	12.40	6.35	57.22	24.20	12.07	6.51	57.54	23.80	12.24	6.43

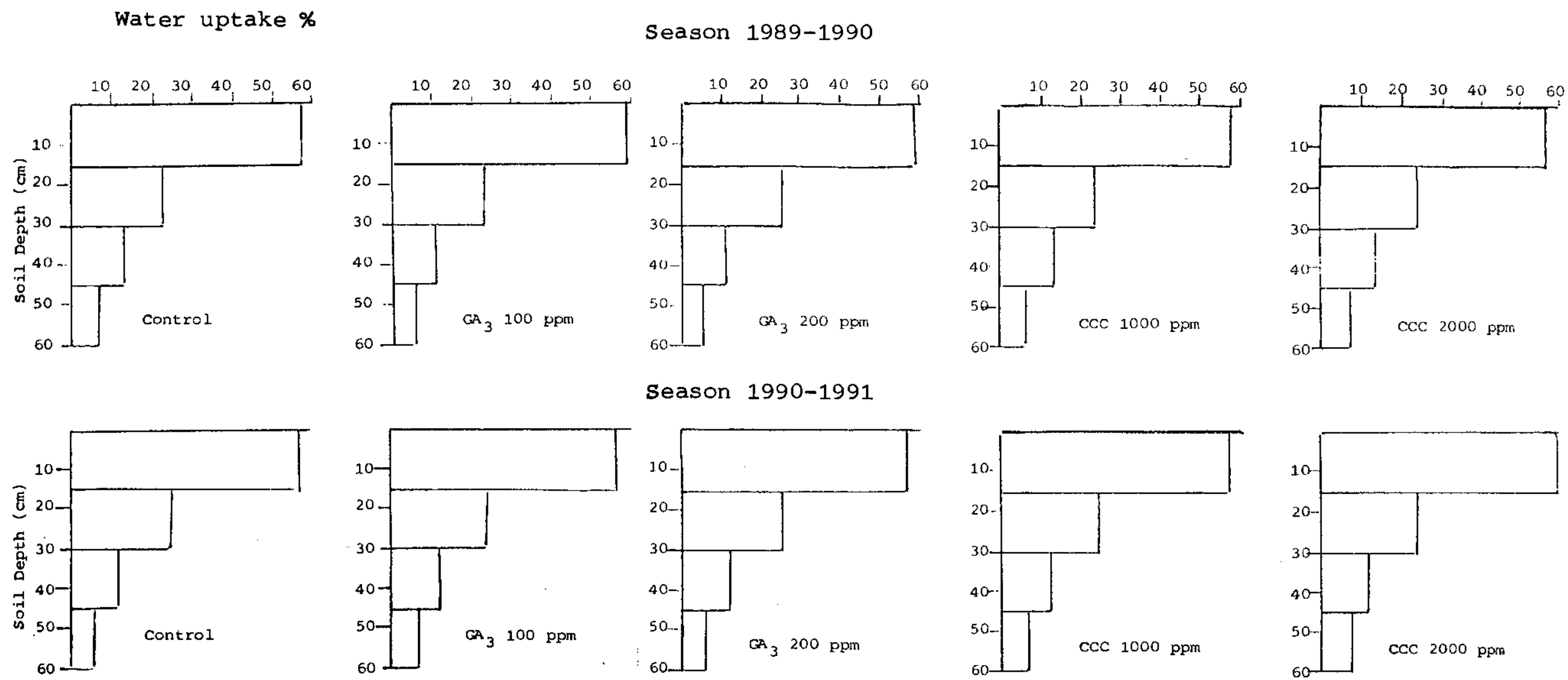


Fig. (3):- Soil water uptake pattern by Potato roots for different growth regulator treatments in fall plantation.

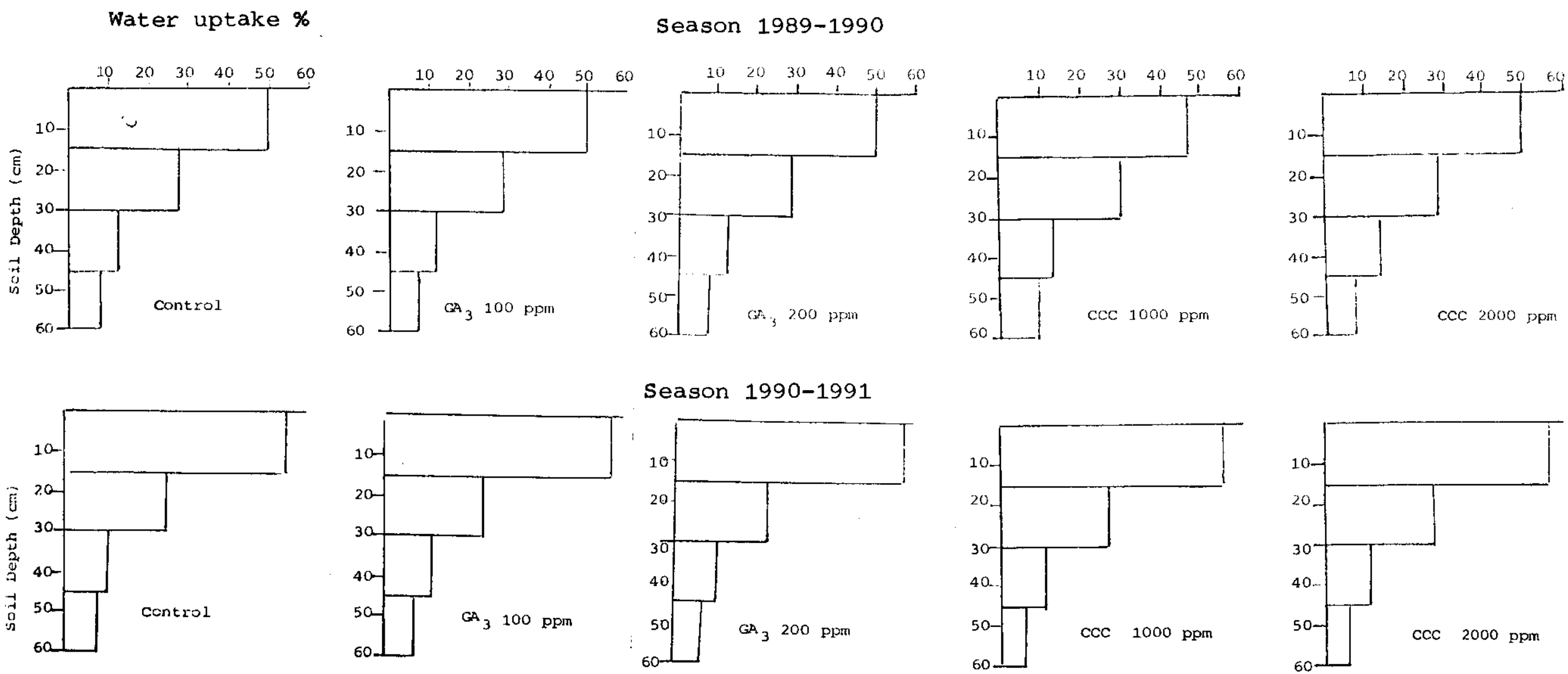


Fig. (4):- Soil water uptake pattern by potato roots for different growth regulator treatments in Summer plantation.

either by increasing crop productivity or decreasing losses due to evapotranspiration. Crop productivity depends on such plant factors as gains due to photosynthesis versus losses due to diseases or pests. Hence, water use efficiency can be influenced by such means dealing with crop production as well as by improvement of water management.

a) Dry matter production :

Water use efficiency expressed as kg dry matter/feddan/ m^3 of water consumed in complete evapotranspiration for potato as affected by growth regulators for fall and summer plantations is presented in Table (44). Results showed that the values of water use efficiency for summer plantation are very low compared with fall plantation. This trend can be discussed on the basis that :

1. Less dry matter produced per unit area in summer plantation compared with the corresponding values of fall.

2. Evapotranspiration in summer was higher than that of fall plantation.

Those two factors are the main reasons of lowering water use efficiency values of summer plantation than the

Table (44):- **Water use efficiency by potato (kg. dry matter/m^3 of water consumed) at various stages of growth as affected by some growth regulator.**

Treatments		Season 1989-1990			Season 1990-1992			Mean of two season		
		Days after planting								
		50	65	80	50	65	80	50	65	80
					Summer plantation					
Control	0	0.61	2.67	2.80	0.95	2.00	1.84	0.78	2.34	2.32
GA_3	100	0.69	1.52	1.43	1.05	1.64	1.19	0.87	1.58	1.31
	200	0.68	1.58	1.21	1.06	1.38	0.90	0.87	1.48	1.06
	$\bar{x}$	0.69	1.55	1.32	1.06	1.51	1.05	0.87	1.53	1.19
CCC	1000	0.68	3.28	2.81	0.92	3.04	2.70	0.80	3.16	2.76
	2000	0.64	3.28	2.77	0.89	3.49	2.64	0.77	3.38	2.71
	$\bar{x}$	0.66	3.28	2.79	0.91	3.27	2.67	0.79	3.27	2.74
$\bar{X}$		0.66	2.47	2.20	0.97	2.31	1.85	0.82	2.39	2.03
					Fall plantation					
Control	0	3.02	4.59	3.08	1.62	4.88	3.16	2.32	4.74	3.12
GA_3	100	3.31	6.08	3.48	1.77	5.82	3.72	2.54	5.95	3.60
	200	3.21	5.64	3.63	1.74	6.17	3.72	2.48	5.91	3.68
	$\bar{x}$	3.26	5.86	3.56	1.76	6.00	3.72	2.51	5.93	3.64
CCC	1000	3.51	6.62	4.16	1.57	8.21	4.63	2.54	7.42	4.40
	2000	3.57	6.18	3.86	1.58	8.09	4.83	2.58	7.14	4.35
	$\bar{x}$	3.54	6.40	4.01	1.58	8.15	4.73	2.56	7.28	4.38
$\bar{X}$		3.32	5.82	3.64	1.66	6.63	4.01	2.49	6.23	3.83

corresponding ones of fall.

Water use efficiency values were low at earlier periods of potato growth because the green cover had not been established yet and dry matter production is very low. Thereafter, water use efficiency values reached its maximum values i.e. when plants aged 65 days. This trend was found to be obvious in both plantations i.e. summer or fall. During such period the canopy covered the ground and light interception was at a maximum rate as the leaf area index was high. After that, water use efficiency values started to decrease again as the plants began to mature. In this connection, Abbas (1992) concluded that water use efficiency was lower in the first period of growth (from emergence to 50 days) then reached a maximum from 50 to 75 days. Thereafter water use efficiency redecreased again to reach a minimum at the end of the season.

Concerning the effect of growth regulators on water use efficiency values, results of Table (44) indicate that GA_3 affects greatly the values of water use efficiency. Such effect depends upon the growing season. In other words, the effect of GA_3 on the values of water use efficiency in summer plantation differs completely than that obtained from fall plantation. In summer plantation, the use of GA_3 with low or high rate decreased the values of water use efficiency at later stages of growth i.e. 65 or 80 days after planting. Such reduction was enhanced by increasing the rate of GA_3 application from 100 to 200 ppm. However, a slight increase in water use efficiency was observed at earlier stages of potato growth (50 days from planting) by the use of GA_3. The previous results can be ascribed to the effect of GA_3 on tuberization. In summer plantation, the plant directed some of its effort on producing of flowers which affects the production of tubers. The dry matter production/plant in summer was less than the control due to less tuber weight. Such decrease in dry matter did result in low water use efficiency values for plots sprayed with GA_3. The reverse trend to that observed in summer plantation was found from fall plantation. The use of GA_3 improved the values of water use efficiency. In other words, the application of GA_3 at both used rates did result in increasing the values of water use efficiency compared with the control. This pattern of results is mainly due to higher dry matter production and tubers in fall plantation compared with summer. Also, the day length is not so enough to induce the potato plant to flower causing the plant to direct its effort for tuber production. The previous factors resulted in the improvement of water use efficiency values.

In case of the growth retardant (CCC), results of Table (44), showed that the use of such chemical increased the values of water use efficiency in both plantations i.e.fall or summer plantation. The growth retardant decreased the shoot system while increased tuber production. At the same time, evapotranspiration was decreased. Those two factors resulted in increasing water use efficiency values compared with the control or those plants sprayed with GA_3. It can be concluded that for better water use efficiency values, potato plant can be sprayed with a growth retardant (CCC) in both plantation i.e. fall or summer. However, in case of GA_3, it can be used in fall plantation only. Thus, the use of GA_3 in summer plantation can not be recommended from the stand point of water use efficiency.

b) Tuber yield :

Water use efficiency expressed as kg of tuber yield/ feddan/m^3 of water consumed in fall and summer plantations as affected by growth regulators is presented in Table (45). Results indicate that water use efficiency values for fall plantation were higher than that observed in summer. The lower values of water use efficiency observed in summer plantation is mainly due to less tuber production in summer than fall plantation. Also, water consumption in summer was found to be higher than fall plantation. When, the numerator

Table (45):- **Water** use efficiency by potato as affected by some growth regulator.

Treatments		Summer plantation			Fall plantation		
		Season 89- 90.	Season 90- 91	Mean	Season 89- 90	Season 90- 91	Mean
		Kg. Tuber yield/feddan/m^3 ET					
Control	0	4.12	4.90	4.51	8.06	7.19	7.63
GA_3	100	3.45	3.71	3.58	9.33	7.58	8.46
	200	3.26	3.42	3.34	8.11	6.56	7.34
	$\bar{x}$	3.36	3.57	3.46	8.72	7.07	7.90
CCC	1000	6.52	7.04	6.78	13.31	11.46	12.39
	2000	6.74	6.19	6.47	13.26	11.96	12.61
	$\bar{x}$	6.63	6.62	6.63	13.29	11.71	12.50
$\bar{\bar{X}}$		4.82	5.05	4.94	10.41	8.95	9.68
		Kg.Tuber dry matter/feddan/m^3 ET					
Control	0	0.96	1.23	1.10	1.85	1.78	1.82
GA_3	100	0.83	0.94	0.89	2.25	2.03	2.14
	200	0.78	0.86	0.82	2.07	1.70	1.89
	$\bar{x}$	0.81	0.90	0.86	2.16	1.87	2.02
CCC	1000	1.58	1.90	1.74	3.34	3.24	3.29
	2000	1.81	1.70	1.76	3.63	3.17	3.40
	$\bar{x}$	1.70	1.80	1.75	3.49	3.21	3.35
$\bar{\bar{X}}$		1.19	1.33	1.26	2.63	2.38	2.51

was decreased and the denumorator increased, in the ratio, lower values were gained. This may explain why water use efficiency values obtained in summer plantation are very low compared with fall plantation.

Regarding the effect of GA_3 on the values of water use efficiency, results did not behave in the same manner according to the growth season i.e. fall or summer plantation. In summer plantation, the use of GA_3 decreased the values of water use efficiency. Such decrease was slightly inhanced by the higher rate of GA_3. This trend can be ascribed to less tuber production in summer plantation. On the contrary, the application of GA_3 in fall plantation slightly improved the values of water use efficiency compared with the control. This trend occurred at the low rate of GA_3, while a slight reduction in water use efficiency values were gained from the higher application rate of GA_3.

As for CCC, results of Table (45) showed that the use of this growth retardant, a marked increase in the values of water use efficiency was gained. This trend was found to be obvious in both plantations i.e. fall or summer plantation. This type of results is expected as the growth retardants increased tuber yield and at the same time reduced seasonal evapotranspiration.

In this connection, Miseha (1983) concluded that the use of growth regulators may increase dry matter production more than evapotransportation resulting in an increase in water use efficiency. Such chemicals can improve the efficiency of water utilization expressed as dry matter production per unit of water consumed.

4.2.4. Chemical Composition :

4.2.4.1. Mineral composition :

Results of nirogen, phosphorus and potassium concentration expressed as mg/g dry matter for leaves,stems and tubers of potato plant at various stages of growth as affected by some growth regulators are presented in Tables(46,47 and 48).

a) Nitrogen :

Nitrogen concentration of leaves and stems increased by advancing age up to 65 days then slightly decreased. Such decrease observed in the last sample (80 days) may be due to the translocation of nitrogenous compound to the storage organ. However, nitrogen showed a reverse trend to that observed with leaves or stems. In other words, nitrogen content decreased gradually as the tubers developed. this reduction in nitrogen concentration of tubers might be related to the increase in tuber size by accumulation of carbohydrate compounds.

It can be mention that leaves had higher nitrogen content than those of stems or tubers. Also, tubers are the least in nitrogen concentration compared with other plant organs. Such pattern was found to be clear throughout the growth cycle of the plant. Tubers mostly store carbohydrates rather than any other compounds. It is worthy to mention that

Table (46):- **Effect of some growth regulators on nitrogen concentration (mg.N/g. dry matter)of leaves,stems and tubers at different periods of potato growth.**

Treatments	Conc. (ppm)	Leaves 50	Leaves 65	Leaves 80	Stems 50	Stems 65	Stems 80	Tubers 50	Tubers 65	Tubers 80
		Days after planting								
					Summer plantation					
Control	0	27.5	37.5	34.5	12.5	20.0	17.5	12.0	10.0	7.5
GA_3	100	23.0	37.5	33.5	11.0	15.0	12.5	12.0	8.5	7.5
	200	22.5	34.5	32.5	10.0	15.0	13.0	8.5	7.5	6.0
	$\bar{x}$	22.8	36.0	33.0	10.5	15.0	12.8	10.3	8.0	6.8
CCC	1000	35.0	39.0	36.0	17.5	22.5	20.0	13.0	12.5	12.0
	2000	28.0	38.0	35.0	16.0	21.0	18.0	12.5	11.0	8.5
	$\bar{x}$	31.5	38.5	35.5	16.8	21.8	19.0	12.8	11.8	10.3
$\bar{X}$		27.2	37.3	34.3	13.4	18.7	16.2	11.6	9.9	8.3
					Fall plantation					
Control	0	36.5	42.8	41.8	17.5	26.0	24.0	-	17.5	16.5
GA_3	100	40.0	60.0	45.1	22.5	30.0	25.5	-	22.5	16.0
	200	37.5	48.5	44.0	18.0	26.5	20.0	-	18.0	17.5
	$\bar{x}$	38.8	54.3	44.6	20.3	28.3	22.8	-	20.3	16.8
CCC	1000	46.4	67.5	45.8	26.0	35 0	32.5	-	28.0	22.5
	2000	43.0	63.0	44.0	21.5	32.5	27.5	-	26.5	16.0
	$\bar{x}$	44.7	65.3	44.9	23.8	33.8	30.0	-	27.3	19.3
$\bar{X}$		40.7	56.4	44.1	21.1	30.0	25.9	-	22.5	17.7

Table (47):- Effect of some growth gregulators on phosphorus concentration (mg.P./g dry matter) of leaves, stems and tubers at different periods of potato growth.

Treatments	Conc. (ppm)	Leaves			Stems			Tubers		
		Days after planting								
		50	65	80	50	65	80	50	65	80
					Summer plantation					
Control	0	2.50	3.20	2.60	1.60	3.00	2.00	1.20	2.20	2.60
GA_3	100	2.00	2.50	2.50	1.50	2.60	1.70	1.20	1.80	2.50
	200	1.40	2.50	2.00	1.20	2.40	1.20	1.20	1.70	1.70
	$\bar{x}$	1.70	2.50	2.25	1.35	2.50	1.45	1.20	1.75	2.10
CCC	1000	3.00	4.60	3.50	2.00	3.70	3.10	1.50	2.60	3.20
	2000	2.60	3.20	3.20	1.70	3.20	2.60	1.40	2.50	2.60
	$\bar{x}$	2.80	3.90	3.35	1.85	3.45	2.85	1.45	2.55	2.90
$\bar{X}$		2.30	3.20	2.76	1.60	2.98	2.12	1.30	2.16	2.52
					Fall plantation					
Control	0	1.00	2.70	2.40	1.00	2.40	1.40	-	1.20	2.00
GA_3	100	1.20	3.60	3.00	1.40	3.60	1.60	-	2.50	2.60
	200	1.20	3.20	2.60	1.40	3.00	1.60	-	1.70	2.40
	$\bar{x}$	1.20	3.40	2.80	1.40	3.30	1.60	-	2.10	2.50
CCC	1000	2.00	3.70	3.20	1.60	3.90	2.20	-	3.10	3.50
	2000	2.50	3.60	3.10	1.60	3.80	2.20	-	3.00	3.20
	$\bar{x}$	2.25	3.65	3.15	1.60	3.85	2.20	-	3.05	3.35
$\bar{X}$		1.58	3.36	2.86	1.40	3.34	1.80	-	2.30	2.74

Table (48):- Effect of some growth gregulators on potassium concentration (mg.K/g dry matter) of leaves, stems and tubers at different periods of potato growth.

Treatments	Conc. (ppm)	Leaves 50	Leaves 65	Leaves 80	Stems 50	Stems 65	Stems 80	Tubers 50	Tubers 65	Tubers 80
		Days after planting								
					Summer plantation					
Control	0	48.0	46.3	30.0	62.5	85.0	70.5	27.5	26.3	25.0
GA_3	100	45.0	40.0	30.0	53.8	81.3	52.5	33.8	31.9	27.5
	200	46.3	45.0	33.8	52.5	81.3	59.4	31.9	31.3	27.5
	$\bar{x}$	45.7	42.5	31.9	53.2	81.3	56.0	32.9	31.6	27.5
CCC	1000	55.6	46.3	45.0	69.4	87.5	75.0	31.9	26.3	21.9
	2000	55.6	48.8	43.8	69.4	87.5	76.3	38.8	28.8	25.0
	$\bar{x}$	55.6	47.6	44.4	69.4	87.5	75.7	35.4	27.6	23.5
$\bar{X}$		50.1	45.3	36.5	61.5	84.5	66.7	32.8	28.9	25.4
					Fall plantation					
Control	0	56.9	41.3	32.5	68.8	82.5	81.9	-	32.5	28.8
GA_3	100	55.6	52.5	47.5	85.0	85.0	72.5	-	36.3	26.9
	200	48.8	41.3	41.3	75.0	95.0	73.8	-	38.1	26.3
	$\bar{x}$	52.2	46.9	44.4	80.0	90.0	73.2	-	37.2	26.6
CCC	1000	55.0	55.9	45.0	73.8	102.5	93.8	-	33.8	23.6
	2000	58.8	51.3	43.8	91.3	110.0	102.5	-	38.8	26.3
	$\bar{x}$	56.9	53.6	44.4	82.6	106.3	98.2	-	36.3	25.0
$\bar{X}$		55.0	48.5	42.0	78.8	95.0	84.9	-	35.9	26.4

fall plantation process more nitrogen than summer plantation. This trend seemed to be true in the different plant organs which indicates that the growth of potato plant in fall is better than summer plantation.

Concerning the role of growth regulators on nitrogen concentration, results gained from Table (46) showed that the use of GA_3 affects nitrogen concentration and that depends on the season of plantation. In other words, the effect of GA_3 depend to a large extent on the time of plantation (fall or summer) and the organ of the plant. Also, the rate of GA_3 application affects such concentration. When GA_3 rate increased from 100 to 200 ppm, nitrogen concentration decreased in most of sampling periods as well as in the two plantations in different plant organs. It can be mentioned that GA_3 application seemed to decrease nitrogen concentrations of different plant organs in most of sampling periods. However, in fall plantation, leaves showed higher nitrogen content compared with the control. These results are mainly due to the effect of such promoting substances on the absorption and translocation of nitrogenous compounds from leaves to other plant organs. In this respect, Anton (1991) showed that growth substances accelerate the accumulation of nitrogenous compounds in plants by many ways which include the uptake and accumulation of nitrogen in different plant organs.

As for the effect of CCC, results showed that nitrogen concentration increased in different plant organs during different growth periods in both plantations by the use of such growth retardant. Such type of results may be due to the inhibition of potato growth by such compound.

b) **Phosphorus :** Phosphorus concentration of potato leaves, stems and tubers throughout its growth cycle as affected by growth regulators is presented in Table (47). Results showed that phosphorus concentration increased gradually to reach a maximum when potato plant aged 65 days then slightly decreased after that. Such decrease was found to be true in leaves and stems only, while P concentration increased continously up to the last sample in tuber. The decrease in P concentration after the second sample may be related to the translocation to the storage organ of the plant (tubers). The previous results are similar in both plantations i.e. fall or summer. It is worthy to mention that leaves are higher in P concentration than either stems or tubers.

Regarding the effect of GA_3 on P content, results showed that GA_3 application reduced P concentration in different plant organs during different periods of growth. This trend was found to be true in summer plantation. However, the reverse of that was obtained in fall plantation. Phosphorus, concentration of the different plant organs increased by GA_3 application during its growth cycle. Such pattern can be related to the effect of GA_3 on the growth of plants thereby to the absorption and translocation of (P).

As for the effect of CCC, results showed that it increased P concentration of leaves,stems and tubers throughout its growth cycle. This pattern was found to be clear in both plantations.

c) **Potassium :** Potassium concentration expressed as mg/g dry matter in different plant organs for fall and summer plantations as affected by GA_3 or CCC levels is presented in Table (48). Results showed that K concentration decreased as the plant developed. This trend was found to be clear in leaves and tubers, while stem showed a continous increase in (K) up to the second sample (65 days), then decreased after that. Potassium concentration of stem seemed to be higher than either leaves or tubers. These results are similar in both plantations.

Regarding the effect of growth regulators i.e. GA_3 or CCC, on(K) concentration, results showed that both substances increased the level of (K) in different plant organs at different periods of growth in fall plantation. The exception of that was gained in summer plantation. The application of GA_3 decreased slightly K concentration in leaves, stems and tubers during different periods of growth. This pattern was observed from both GA_3 rates. However, the application of CCC increased K concentration in different potato plant organs at various stages of growth. It can be concluded that growth regulators affect greatly the growth of plants which was reflected on the absorption and accumulation of K in different plant organs. Such effect depends on the prevailing environmental conditions i.e. the time of growth season.

4.2.4.2. Carbohydrate contents :

Data of carbohydrate concentration (mg.glucose/g dry matter) in leaves, stems and tubers at different periods of potato growth in the two plantations are presented in Tables (49 and 50).

a) Total sugars :

Results showed that total sugars increased gradually up to the second period (65 days) then decreased after that. This trend was found to be true in leaves and stems. While tubers showed a reverse pattern of that observed with both leaves and stems. Total sugars of potato tubers decreased by advancing age. This reduction seemed to be related to changes

Table (49):- **Effect of some growth regulators on the concentration of total sugars (mg.glucose/g. dry matter) of leaves, stems and tubers at different periods of potato growth.**

Treatments	Conc. (ppm)	Leaves 50	Leaves 65	Leaves 80	Stems 50	Stems 65	Stems 80	Tubers 50	Tubers 65	Tubers 80
					Summer plantation					
Control	0	18.9	21.3	19.8	1.5	6.3	4.5	46.4	29.1	20.3
GA_3	100	14.4	21.0	18.4	4.0	6.0	5.5	50.8	31.8	21.5
	200	11.6	21.1	17.9	4.5	5.3	4.8	40.5	34.9	22.2
	$\bar{x}$	13.0	21.1	18.2	4.3	5.7	5.2	45.7	33.4	21.9
CCC	1000	15.6	29.8	24.8	6.0	7.5	7.0	49.8	21.2	17.6
	2000	14.4	29.7	25.5	5.5	7.0	6.8	49.4	21.0	16.2
	$\bar{x}$	15.0	29.8	25.2	5.8	7.3	6.9	49.6	21.1	16.9
$\bar{X}$		15.0	24.6	21.3	4.3	6.4	5.7	47.4	27.6	19.6
					Fall plantation					
Control	0	13.7	28.0	26.6	1.0	3.0	3.3	-	39.9	24.3
GA_3	100	21.4	31.0	28.1	1.0	8.0	6.3	-	51.0	25.5
	200	19.3	29.9	27.7	1.0	9.5	9.0	-	41.8	28.6
	$\bar{x}$	20.4	30.5	27.9	1.0	8.8	7.7	-	46.4	27.1
CCC	1000	29.9	38.8	35.5	2.0	8.0	8.0	-	24.5	20.5
	2000	21.1	39.7	35.4	1.0	7.8	7.9	-	21.6	19.4
	$\bar{x}$	25.5	39.3	35.5	1.5	7.9	8.0	-	23.1	20.0
$\bar{X}$		21.1	33.5	30.7	1.2	7.3	6.9	-	35.8	23.7

Table (50):- **Effect** of some growth regulators on the concentration of total carbohydrate (mg.glucose/g. dry matter) of leaves, stems and tubers at different periods of potato growth.

Treatments	Conc. (ppm)	Leaves			Stems			Tubers		
		Days after planting								
		50	65	80	50	65	80	50	65	80
					Summer plantation					
Control	0	30.0	55.0	43.0	10.0	19.0	10.0	280.0	483.0	560.0
GA_3	100	25.0	65.0	38.0	10.0	15.0	13.9	200.0	385.0	545.0
	200	26.0	65.0	30.0	14.8	19.8	17.3	220.0	313.0	493.0
	$\bar{x}$	25.5	65.0	34.0	12.4	17.4	15.6	210.0	349.0	519.0
CCC	1000	35.0	76.0	39.0	10.5	14.3	12.8	301.0	565.0	825.0
	2000	31.3	75.0	37.0	10.5	19.5	15.0	345.0	500.0	789.0
	$\bar{x}$	33.2	76.0	38.0	10.5	16.9	13.9	323.0	532.5	807.0
$\bar{X}$		29.5	67.2	37.4	11.2	17.5	13.8	269.2	449.2	642.4
					Fall plantation					
Control	0	31.3	45.0	40.0	12.1	12.2	12.2	-	425.0	695.0
GA_3	100	38.0	58.0	55.0	11.8	13.4	12.4	-	505.0	705.9
	200	35.0	58.0	54.0	12.1	13.9	12.1	-	430.0	660.0
	$\bar{x}$	36.5	58.0	54.5	12.0	13.7	12.3	-	467.5	683.0
CCC	1000	43.0	63.5	58.5	12.0	12.1	12.0	-	601.0	855.0
	2000	43.0	68.0	50.1	12.2	12.3	12.3	-	630.0	815.0
	$\bar{x}$	43.0	65.8	54.3	12.1	12.2	12.2	-	615.5	835.0
$\bar{X}$		38.1	58.5	51.5	12.0	12.8	12.2	-	518.2	746.2

of soluble sugars to starch. Also, the decrease in total sugars observed in leaves and stems after the second sample may be due to the translocation of such compounds to the storage organ i.e. tubers. Also, the leaves of potato had higher sugars content than stems. Moreover, leaves, stems and tubers sugar content in fall plantation were higher than the corresponding values of summer plantation. Such pattern can be ascribed to earlier formation of tubers in summer plantation compared with fall. Such earlier formation of tubers requires more carbohydrates which translocate from leaves through stems to the new tubers. This can explain the lower values of total sugars observed in summer plantation when compared with fall.

Regarding the effect of GA_3 and CCC on total sugars, results showed that both growth regulators increased the concentration of total sugars of leaves,stems and tubers than the control. The exception of the previous results was found to be in summer plantation. The use of GA_3 seemed to decrease slightly the amount of total sugars in leaves only when compared with the control.

In this connection, Bozova and Kerin (1980) showed that the application of CCC increased the monosaccharide content of leaves. Differences in leaf sugar contents of treated and control plants disappeared only after planting out in the field. Early sugar accumulation in tomato seedling was due mainly to the stimulation of photosynthesis by CCC. Devlin and Witham (1983) concluded that IAA and GA_3 increased total amount of translocated photosynthetic products and the rate of translocation of such compounds.

b) Total carbohydrates :

Results of total carbohydrates of leaves , stems and tubers for potato plant in both plantations throughout its growth cycle are presented in Table (50). Data indicate that the values of total carbohydrates increased as the plant developed to reach a maximum when plants aged 65 days, then decreased after that. The exception of that was found to be true with tubers which showed a continous increase in total carbohydrate concentration by advancing age. This pattern is mainly due to the translocation of carbohydrates from leaves to the storage organ i.e. tubers. It can be mention that the values of total carbohydrate in fall plantation were higher than the corresponding values of summer. These results may prove that climatic factors affect the growth of potato plant which was reflected on the total carbohydrate content of the various plant organs.

Regarding the effect of GA_3 or CCC on total carbohydrate, results showed that GA_3 or CCC increased the amount of carbohydrate in leaves, stems and tubers in the different tested periods. These results were found to be clear in fall plantation for both substances and CCC only in summer plantation. The exception of that was when GA_3 used in summer plantation. The application of GA_3 with two levels seemed to decrease the amount of total carbohydrate in leaves, stems and tubers. This type of results may indicate that the growth season affects greatly the response of plants to such growth substances. The previous findings are in agreement of Alam and Islam (1989) who concluded that the foliar application of CCC on potato plant increased sugar and starch content of tubers.

4.2.4.3. Leaf Plastid Pigments :

The values of chlorophyll a & b, and caroten in terms of mg/g fresh weight during different growth periods of potato growth is presented in Table (51). Also, the proportion between the different chloroplast pigment fractions were estimated and illustrated in Table (51). Results indicated that chlorophyll a and b increased as the plant developed, however, carotenoides showed slight variations by advancing age.

The two plantations i.e. fall and summer showed some

Table (51):- Effect of some growth regulators on change of different pigment fractions during various stages of potato growth (mg per gm leaves fresh weight).

Treatments		50 days after planting						65 days after planting						80 days after planting					
		a	b	c	a+b	a/b	(a+b)/c	a	b	c	a+b	a/b	(a+b)/b	a	b	c	a+b	a/b	(a+b)/c
Summer plantation																			
Control	0	0.87	0.79	0.46	1.66	1.10	3.61	0.86	1.00	0.45	1.86	0.86	4.13	0.86	1.20	0.44	2.06	0.72	4.68
GA_3	100	0.83	0.78	0.47	1.61	1.06	3.43	0.78	0.98	0.48	1.76	0.80	3.67	0.80	0.99	0.47	1.79	0.81	3.81
	200	0.80	0.72	0.48	1.52	1.11	3.17	0.76	0.96	0.52	1.72	0.79	3.31	0.84	0.96	0.49	1.79	0.88	3.65
	$\bar{x}$	0.82	0.75	0.48	1.57	1.09	3.30	0.77	0.97	0.50	1.74	0.80	3.49	0.82	0.98	0.48	1.79	0.85	3.73
CCC	1000	0.90	0.79	0.45	1.69	1.14	3.76	0.98	1.25	0.40	2.23	0.78	5.58	0.96	1.28	0.38	2.24	0.75	5.89
	2000	0.99	0.79	0.44	1.78	1.25	4.05	0.98	1.26	0.40	2.24	0.78	5.60	0.97	1.30	0.38	2.27	0.75	5.97
	$\bar{x}$	0.95	0.79	0.45	1.74	1.20	3.91	0.98	1.26	0.40	2.24	0.78	5.59	0.97	1.29	0.38	2.26	0.75	5.93
$\bar{x}$		0.88	0.77	0.46	1.65	1.13	3.60	0.87	1.09	0.45	1.96	0.80	4.46	0.89	1.15	0.43	2.03	0.78	4.80
Fall plantation																			
Control	0	0.87	0.75	0.37	1.62	1.16	4.38	0.90	1.06	0.38	1.96	0.85	5.16	0.88	1.03	0.34	1.90	0.85	5.59
GA_3	100	0.86	0.74	0.38	1.60	1.16	4.21	0.80	0.90	0.40	1.70	0.89	4.25	0.86	0.89	0.37	1.75	0.97	4.73
	200	0.86	0.73	0.37	1.59	1.18	4.30	0.79	0.85	0.44	1.64	0.93	3.73	0.77	0.79	0.39	1.56	0.97	4.00
	$\bar{x}$	0.86	0.74	0.38	1.60	1.17	4.26	0.80	0.88	0.42	1.67	0.91	3.99	0.82	0.84	0.38	1.66	0.97	4.37
CCC	1000	0.90	0.86	0.36	1.76	1.05	4.89	1.13	1.31	0.36	2.44	0.86	6.78	1.17	1.25	0.33	2.42	0.94	7.33
	2000	0.93	0.83	0.35	1.76	1.12	5.03	1.27	1.39	0.34	2.66	0.84	7.82	1.26	1.36	0.33	2.62	0.93	7.94
	$\bar{x}$	0.92	0.85	0.36	1.76	1.09	4.96	1.20	1.35	0.35	2.55	0.85	7.30	1.22	1.31	0.33	2.52	0.94	7.64
$\bar{x}$		0.88	0.78	0.37	1.67	1.13	4.56	0.98	1.10	0.38	2.08	0.87	5.55	0.99	1.06	0.35	2.05	0.93	5.92

a = Chlorophyll (a)
b = Chlorophyll (b)
c = Carotene.

variations in the different plastid pigments. This trend can be related to the difference in environmental conditions under both growth seasons. The less concentration of carotenoids observed in fall plantation compared with summer indicate that light intensity i.e. radiation and sun shine duration seemed to have a role on the concentration of photosynthetic pigments. This means that sun shine duration has a role in the regulation of the biosynthesis of such pigments. This may explain the variation in plant growth under the two plantations.

Concerning the effect of GA_3 and CCC on leaf pigments, results showed that both substances affect the photosynthetic pigments either the formation or the balance between their fractions. GA_3 seemed to reduce the concentration of chlorophyll a and b, while CCC increased such concentration. In this respect Alam and Islam (1989) concluded that total chlorophyll content was increased by the use of CCC. However, 100 ppm NAA reduced the values of chlorophyll content.