4. RESULTS AND DISCUSSION

Results presented here are averages of the two seasons. With regard to results of each season, Tables of all parameters regarding each season are given in Appendix (i.e. Tables 1-appx to 10- appx) Results for nutrient uptake concern season 2 only .

4.1. Potato growth

4.1.1. Plant height (Table 6 and Fig. 1):

Under conditions no K fertilization G_1, G_2 and G_3 gave plant heights of 42.89, 51.18 and 58.15 cm respectively indicating that with no K application, more water was associated with increased plant height. Therefore G_2 and G_3 showed increases of 19.3, and 35.6 % respectively over G_1. Under condition of K fertilization plant height was much greater and ranged from 49.17 at (G_1 K_1 M_1) to 72.33 cm at (G_3 K_3 M_2) indicating that application of K, was associated with greater plant height.

I- Response to irrigation:

The main effect of irrigation treatments shows that plant height due to G_1,G_2 and G_3 treatments averaged 53.86, 61.88 and 69.28 cm respectively, indicating a superiority of G_2 and G_3 over G_1 with increases of 14.9 and 29.0% respectively. Excess water seemed to have encouraged plant growth in terms

Table (6): Effect of irrigation scheduling treatments (G), potassium application method (M) and rate (K) on plant height (cm) 90-day growth (means of 2 seasons).

K- application		Irrigation treatment (G)			
Method (M)	Rate (K)	G_1	G_2	G_3	Mean
M_1	K_1	49.17	56.00	66.16	**57.11**
	K_2	54.00	61.33	68.67	**61.33**
	K_3	56.83	65.33	70.50	**64.22**
Mean		53.33	60.89	68.44	**60.89**
M_2	K_1	50.67	57.50	68.17	**58.78**
	K_2	54.83	64.50	69.83	**63.05**
	K_3	57.67	66.66	72.33	**65.55**
Mean		54.39	62.88	70.11	**62.46**
Grand mean		**53.86**	**61.88**	**69.28**	**61.67**
Means of K treatments					
K_1		49.92	56.75	67.16	**57.94**
K_2		54.41	62.91	69.25	**62.19**
K_3		57.25	66.00	71.42	**64.89**
Treatments not receiving K					
		G_1	G_2	G_3	Mean
		42.89	51.18	58.15	**50.74**

L.S.D	at 0.05	at 0.01
G	0.82	1.10
K	0.82	1.10
M	0.67	0.89
GK	1.42	1.9
GM	n.s	n.s
MK	n.s	n.s
GKM	n.s	n.s

Notes :

Irrigation scheduling: evaporation pan coefficient (EF) as follows:

G_1: EF 0.8 (Long intervals)

G_2: EF 1.0 (Medium intervals)

G_3: EF 1.2 (Short intervals)

K_1, K_2 and K_3: 100, 133 and 166 kg K/f.

M_1; K applied in dose at with 1st irrigation.

M_2; K applied in 2 equal doses with 1st and 2nd irrigation.

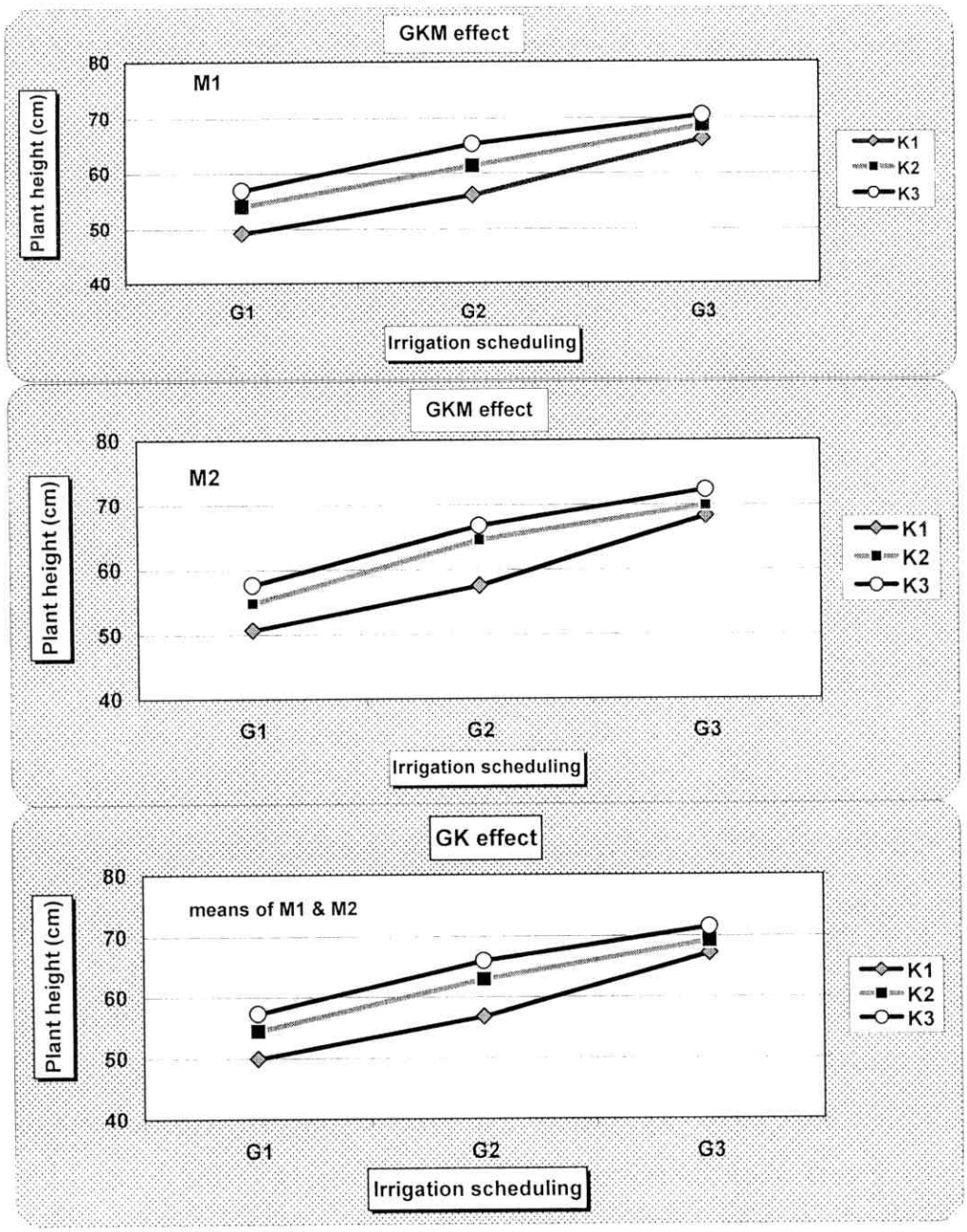

Figure (1): Effect of irrigation scheduling treatments (G), potassium application methods (M) and rate (K) on plant height (cm) 90 day growth.

Irrigation scheduling: evaporation pan coefficient (Ef) as follows:
G1: Ef 0.8 (Long intervals) G2: Ef 1.0 (Medium intervals) G3: Ef 1.2 (Short intervals)
K1, K2 and K3: 100, 133 and 166 kg K/f .
M1; K applied in dose at with 1st irrigation. M2; K applied in 2 equal doses with 1st and 2nd irrigation.

of height. There was no interaction due to K fertilization affecting such a pattern of response.

II- Response to K application:

All treatments receiving K exceeded the non fertilized ones. Overall means show that fertilized treatments increased by an average of 21.5% by K fertilization. The highest was given by K_3 and the lowest was by K_1. Mean values were as follows: K_3 gave the highest height of 64.89 followed by K_2 which gave 62.19, then K_1 which gave 57.94 cm. Therefore K_2 and K_3 showed increases over K_1 amounting to 7.3 and 11.9 % respectively. However, there was significant interaction caused by irrigation and affected K application rate. This was manifested when K_2 and K_3 gave plants of similar height under conditions of G_3. Splitting application gave plants of greater height, an increase of about 3 %.

These results are in harmony with those reported by **El-Banna *et al.* (2001)** who found that plant height significantly increased with increasing the amount of irrigation water. **Abd El-Razik (1996 a)** stated that increasing irrigation water increased plant height of potato plants. **Rabie (1996)** reported that potato plant height was significantly increased with increasing NPK fertilizers. **Sharma *et al.* (1984), El-Gamal (1985), and Shehata and Abo Sedera (1993)** reported that application of K increased potato plant height. On the other

hand **Hassan *et al.* (1985) and Mazullah-Khan *et al.* (1990)** applied up to 80 kg K/f and obtained no considerable positive effect on potato plant height. **Abd El-Razik (1996 a)** stated that increasing irrigation water increased plant height.

4.1.2. Weight of fresh matter of above ground parts of 90 - day plant growth (Table 7 and Fig. 2):

Fresh weight (g/plant) for plants not receiving K were 112.1, 146.1 and 170.1 g/plant under irrigation treatments of G_1, G_2 and G_3 respectively indicating that with no K application, more water was associated with increased fresh weight. Therefore G_2 and G_3 showed increases over G_1 amounting to 30.3 % and 51.7 % respectively. Under conditions of K fertilization, fresh weight was much greater and ranged from 181.7 at (G_1 K_1 M_1) to 309.7 g/plant (G_2 K_3 M_2).

I- Response to irrigation:

The main effect of irrigation treatments shows that the fresh weight/plant was highest by G_3, followed by G_2, and the lowest was that of G_1. Mean values of fresh weight (g/plant) were as follows: 280.3, 267.4 and 184.6 g respectively. Therefore G_2 and G_3 showed increases over G_1 of 44.8 and 51.8 % respectively. There was an interaction caused by K fertilization; under conditions of K_2, G_2 was similar to G_3 thus with a medium K rate there was no superiority of the G_3 irrigation over the G_2 irrigation.

Table (7):Effect of irrigation scheduling treatments (G), potassium application method (M) and rate (K) on plant fresh weight of above-ground parts (g /plant) 90 -day growth (mean of 2 seasons).

K- application		Irrigation treatment (G)			
Method (M)	Rate (K)	G_1	G_2	G_3	Mean
M_1	K_1	181.7	228.1	265.7	**225.1**
	K_2	183.7	278.5	270.8	**244.3**
	K_3	185.7	258.6	292.6	**245.6**
Mean		183.7	255.1	276.3	**238.3**
M_2	K_1	183.2	252.0	274.2	**236.4**
	K_2	183.7	277.6	277.2	**246.1**
	K_3	190.0	309.7	301.5	**267.0**
Mean		185.6	279.7	284.3	**249.9**
Grand mean		**184.6**	**267.4**	**280.3**	**244.1**
Means of K treatments					
K_1		182.4	240.0	269.9	**230.8**
K_2		183.7	278.0	274.0	**245.2**
K_3		187.8	284.1	297.0	**256.3**
Treatments not receiving K					
		G_1	G_2	G_3	Mean
		112.1	146.1	170.1	**142.8**

L.S.D	at 0.05	at 0.01
G	3.9	5.2
K	3.9	5.2
M	3.2	4.2
GK	6.7	8.9
GM	n.s	n.s
MK	5.5	7.3
GKM	5.4	12.6

Notes :

Irrigation scheduling: evaporation pan coefficient (EF) as follows:

G_1: EF 0.8 (Long intervals)

G_2: EF 1.0 (Medium intervals)

G_3: EF 1.2 (Short intervals)

K_1, K_2 and K_3: 100, 133 and 166 kg K/f.

M_1; K applied in dose at with 1st irrigation.

M_2; K applied in 2 equal doses with 1st and 2nd irrigation.

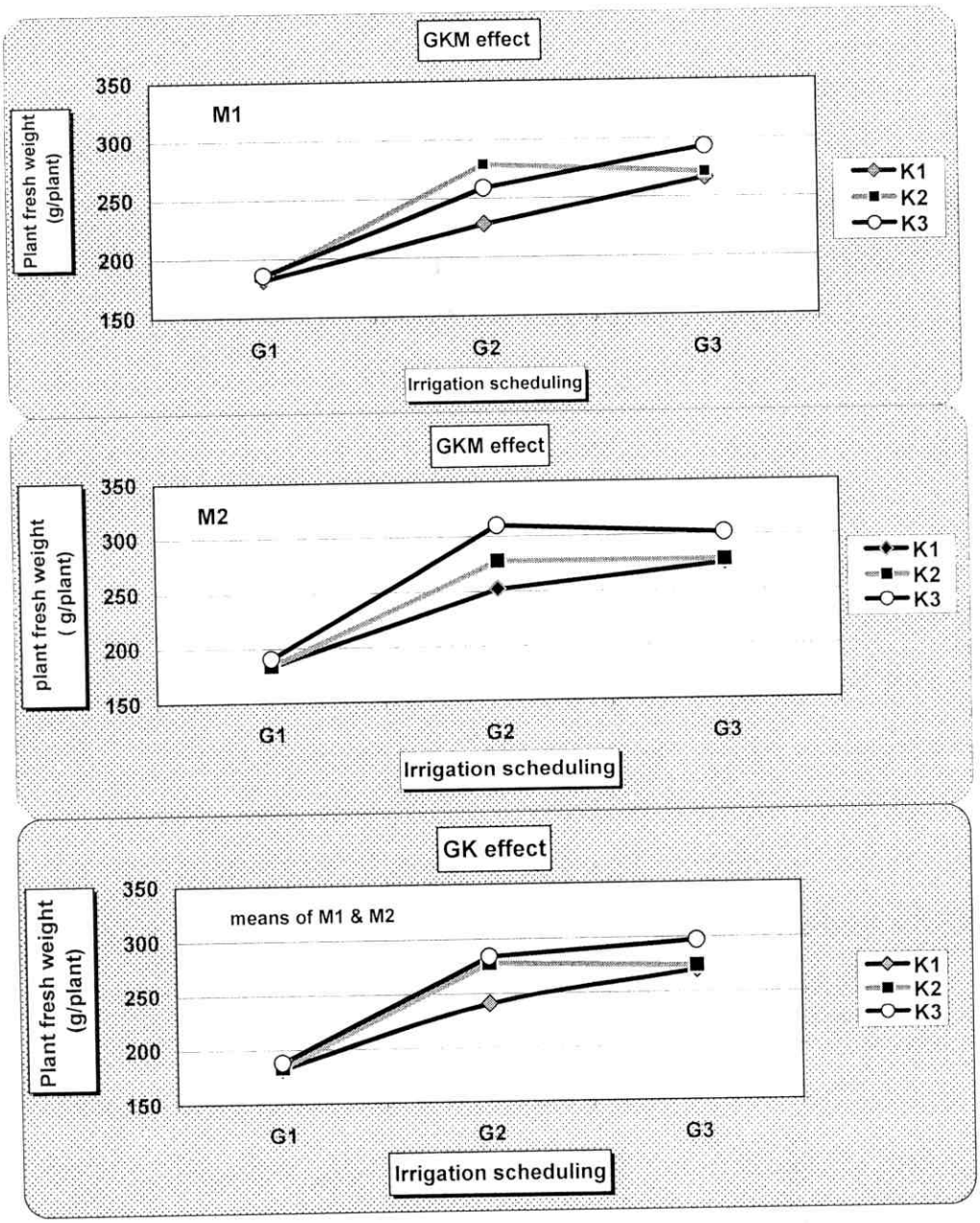

Figure (2): Effect of irrigation scheduling treatments (G), potassium application methods (M) and rate (K) on plant fresh weight of above-ground growth (g/plant) 90 day growth.

Irrigation scheduling: evaporation pan coefficient (Ef) as follows:
G1: Ef 0.8 (Long intervals) G2: Ef 1.0 (Medium intervals) G3: Ef 1.2 (Short intervals)
K1, K2 and K3: 100, 133 and 166 kg K/f .
M1; K applied in dose at with 1st irrigation. M2; K applied in 2 equal doses with 1st and 2nd irrigation.

II- Response to K application:

The main effect of fertilizer shows that all K rates increased the fresh weight per plant as compared with the no fertilizer treatment. The highest weight among the fertilized treatments was that of K_3, and the lowest was that of K_1. Mean values were as follows 230.8, 245.2 and 256.3 g/plant by applying K_1, K_2 and K_3 respectively.

There was an interaction caused by irrigation: under conditions of G_1, the three rates of K were rather similar in effect; under condition of G_3, the low and medium rates of K_1 and K_2 were rather similar in effect and under conditions of G_3 the highest K_3 rate gave the highest response. Therefore, the efficiency of applied K is greater when water was abundant. In a 3 factor interaction the G_3 was most effective where K was at its highest rate and applied as one dose.

This indicates that with more water, plants would grow their roots more to absorb more K even with deeper movement of K in the soil profile. **El-Banna *et al.* (2001) and Abd El-Razik (1996 a)** found that foliage fresh weight/plant increased with increasing the amount of irrigation water. **Gameh *et al.* (2000)** found that under drip irrigation, the 60 mm water regime recorded higher foliage weight over the 30 mm one. **Hartmann *et al.* (1986)** and **Abd Alla *et al.* (1990)** reported

that the highest irrigation level resulted in the highest plant growth and growth parameters **Abou-Hussein (2005)** showed that the increasing K increased fresh weigh of haulm of potato plant.

4.1.3. Weight of dry matter of above ground parts of 90 – day plant growth (Table 8 and Fig. 3):

Effect of irrigation treatments G_1, G_2 and G_3 in absence of K was 22.14, 28.86 and 34.02 g/plant respectively. Therefore G_2 and G_3 showed increases of 30.3 and 53.7 % respectively over G_1.

Under conditions of K fertilization the lowest dry matter was 29.91 g/plant (G_1 K_1 M_2) and the highest was 52.16 g/plant (G_3 K_2 M_2).

I- Response to irrigation:

The main effect of irrigation shows that G_3 gave the highest plant dry weight followed by G_2, then G_1. Mean values (g/plant) were as follows: G_3 = 50.83, G_2 = 41.72 and G_1 = 32.57. This indicates a superiority of G_2 and G_3 over G_1 giving increases of 28.1 and 56.1 % respectively. The increase by G_2 and G_3 over $G_1$was more pronounced under conditions of medium and high K fertilizations.

Table (8): Effect of irrigation scheduling treatments (G), potassium application method (M) and (K) on plant dry weight of above-ground growth (g/plant) 90 -day growth (mean of 2 seasons).

K- application		Irrigation treatment (G)			
Method (M)	Rate (K)	G_1	G_2	G_3	Mean
M_1	K_1	31.17	34.43	49.21	**38.27**
	K_2	33.95	41.82	50.04	**41.94**
	K_3	33.82	46.47	53.37	**44.55**
Mean		32.98	40.91	50.87	**41.59**
M_2	K_1	29.91	36.64	49.66	**38.74**
	K_2	32.77	45.98	52.16	**43.63**
	K_3	33.82	44.99	50.57	**43.13**
Mean		32.17	42.54	50.79	**41.83**
Grand mean		**32.57**	**41.72**	**50.83**	**41.71**
Means of K treatments					
K_1		30.54	35.53	49.44	**38.50**
K_2		33.36	43.90	51.10	**42.79**
K_3		33.82	45.73	51.97	**43.84**
Treatments not receiving K					
		G_1	G_2	G_3	Mean
		22.14	28.86	34.02	**28.34**

L.S.D	at 0.05	at 0.01
G	0.95	1.28
K	0.95	1.28
M	n.s	n.s
GK	1.65	2.21
GM	n.s	n.s
MK	1.35	1.81
GKM	2.34	3.13

Notes :

Irrigation scheduling: evaporation pan coefficient (EF) as follows:

G_1: EF 0.8 (Long intervals)

G_2: EF 1.0 (Medium intervals)

G_3: EF 1.2 (Short intervals)

K_1, K_2 and K_3: 100, 133 and 166 kg K/f.

M_1; K applied in dose at with 1st irrigation.

M_2; K applied in 2 equal doses with 1st and 2nd irrigation.

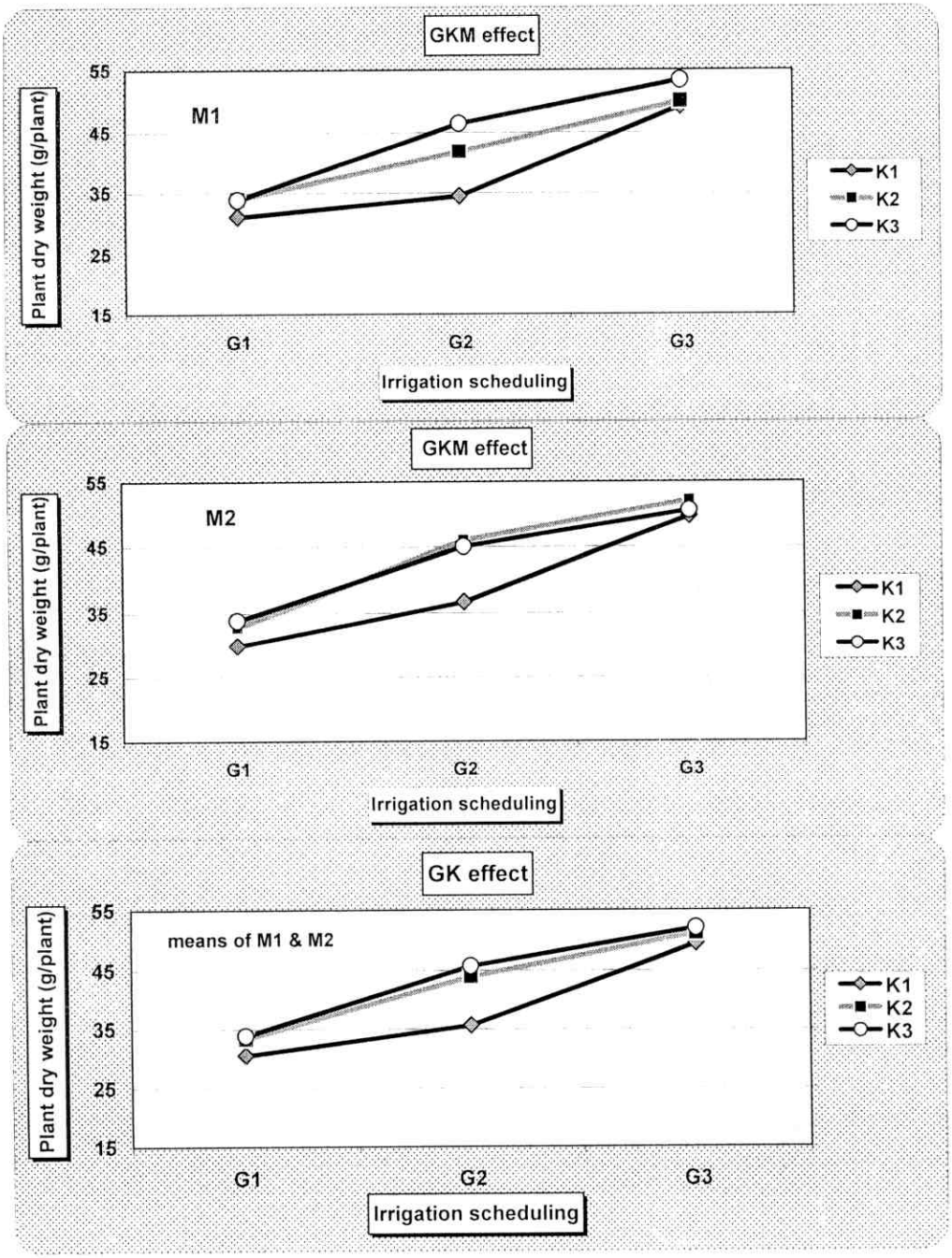

Figure (3): Effect of irrigation scheduling treatments (G), potassium application methods (M) and rate (K) on plant dry weight of above-ground growth (g/plant).

Irrigation scheduling: evaporation pan coefficient (Ef) as follows:
G1: Ef 0.8 (Long intervals) G2: Ef 1.0 (Medium intervals) G3: Ef 1.2 (Short intervals)
K1, K2 and K3: 100, 133 and 166 kg K/f .
M1; K applied in dose at with 1st irrigation. M2; K applied in 2 equal doses with 1st and 2nd irrigation.

On the other hand, the G_2 treatment gave a non - significant increase over G_1 where the rate of K was lowest (K_1) and applied in one dose. This indicates that applying a low K rate in one dose does not allow greater water application to show its positive effect. Splitting such a low rate of K_1 caused the G_2 water treatment to give a marked and significant 22.5 % increase.

II- Response to K application:

The main effect of fertilizer treatments shows that treatments receiving K gave more dry matter than those not given K. The highest dry matter among the three rates of fertilizer treatments was given by K_3 followed by K_2. The lowest was given by K_1. Values of mean plant dry weight (g/plant) were as follows: K_3 = 43.84, K_2 = 42.79 and K_1 = 38.50. Therefore K_2 and K_3 showed increases of 11.1 and 13.8 % respectively. According to the main effect, there was no significant difference between one – dose and split-dose applications.

4.1.4 Tuber dry weight/plant after 90 – day of growth (Table 9 and Fig 4):

The effect of irrigation shows that under no K fertilizer, the weight values of tubers of irrigation treatments G_1, G_2 and G_3 were 87.8, 100.7 and 109.0 g/plant respectively. Therefore G_2 and G_3 showed increases of 14.7 and 24.2 % respectively.

Under conditions of K fertilization the weight of tubers was greater and ranged from 110.8 (G_1 K_1 M_1) to 144.0 g/plant (G_3 K_3 M_2).

I- Response to irrigation:

The main effect of irrigation treatments shows that G_3 gave the highest tuber dry weight followed by G_2, then G_1. Mean values (g/plant) were as follows: G_3 = 134.1, G_2 = 129.2 and G_1 = 119.8 thus G_2 and G_3 gave 7.86 and 11.7 % more weight respectively over G_1. The superiority of G_3 over G_2, however was significant only where the rate of K was G_2 or G_3. Under conditions of K_1, the G_3 treatment was not superior (in fact it was inferior, though not significantly) to G_2. This indicates that for the G_3 treatment to give its full positive effect, a high K rate in necessary.

II- Response to K application:

The fertilized treatments gave more tuber dry weight than the unfertilized ones. The highest tuber dry weight among the fertilized treatments was given by K_3 followed by K_2 and the lowest was that given by K_1. Mean values of tuber dry weight (g/plant) were as follows: K_3 = 135.0, K_2= 128.6 and K_1= 119.5. The average increases were 7.5 and 12.8 % for K_2 and K_3 respectively over K_1. However, superiority of K_2 over K_1 was significant only under G_1 or G_3; under G_2, both K_2 and K_1 were rather similar.

Table (9): Effect of irrigation scheduling treatments (G), potassium application method (M) and rate (K) on tuber dry weight (g/plant) 90 - day growth (mean of 2 seasons).

K- application		Irrigation treatment (G)			
Method (M)	Rate (K)	G_1	G_2	G_3	Mean
M_1	K_1	110.77	122.90	121.65	**118.43**
	K_2	119.60	128.00	134.85	**127.48**
	K_3	126.05	133.40	141.00	**133.48**
Mean		118.80	128.10	132.50	**126.38**
M_2	K_1	112.25	125.80	123.77	**120.61**
	K_2	121.15	128.80	139.30	**129.75**
	K_3	129.00	136.50	144.01	**136.48**
Mean		120.80	130.37	135.67	**129.10**
Grand mean		119.80	129.23	134.09	**127.71**
Means of K treatments					
K_1		111.50	124.35	122.71	**119.52**
K_2		120.38	128.40	137.08	**128.62**
K_3		127.53	134.95	142.48	**134.98**
Treatments not receiving K					
		G_1	G_2	G_3	Mean
		87.78	100.65	109.02	**99.15**
L.S.D		at 0.05		at 0.01	
	G	2.51		3.36	
	K	2.51		3.36	
	M	2.03		2.66	
	GK	2.75		4.35	
	GM	n.s		n.s	
	MK	n.s		n.s	
	GKM	n.s		n.s	

Notes :

Irrigation scheduling: evaporation pan coefficient (EF) as follows:

G_1: EF 0.8 (Long intervals)

G_2: EF 1.0 (Medium intervals)

G_3: EF 1.2 (Short intervals)

K_1, K_2 and K_3: 100, 133 and 166 kg K/f.

M_1; K applied in dose at with 1st irrigation.

M_2; K applied in 2 equal doses with 1st and 2nd irrigation.

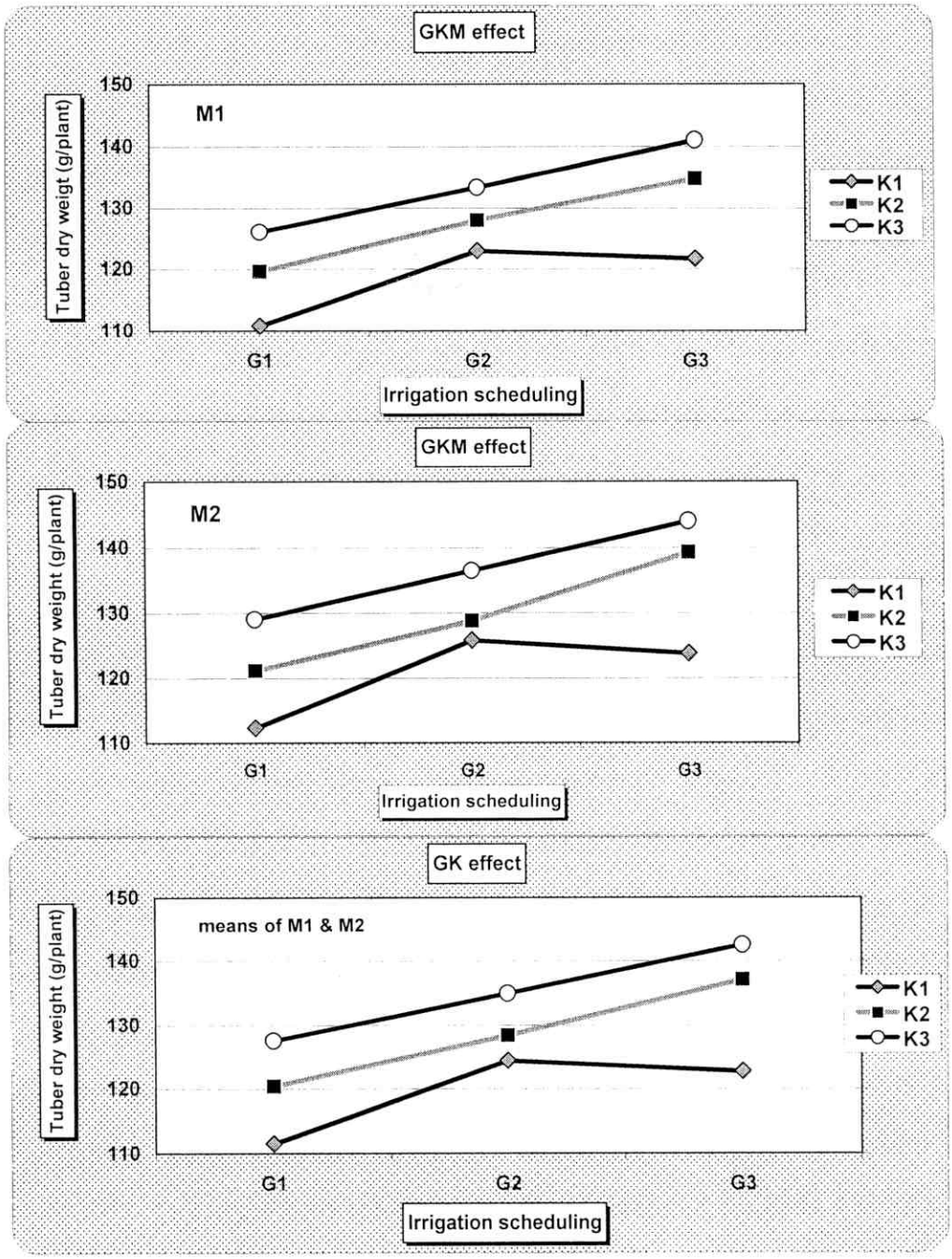

Figure (4): Effect of irrigation scheduling treatments (G), potassium application methods (M) and rate (K) on tuber dry weight (g/plant).

Irrigation scheduling: evaporation pan coefficient (Ef) as follows:
G1: Ef 0.8 (Long intervals) G2: Ef 1.0 (Medium intervals) G3: Ef 1.2 (Short intervals)
K1, K2 and K3: 100, 133 and 166 kg K/f .
M1; K applied in dose at with 1st irrigation. M2; K applied in 2 equal doses with 1st and 2nd irrigation.

The M_2 showed an average greater and significant 2.1 % of tuber dry weight over M_1. However, the interactions between irrigation and K rate, is manifested when K_1 and K_2 were similar under conditions G_2, otherwise K_2 was superior to K_1. This shows that higher yield due to increased K from low to medium levels occurred under low irrigation, due to a possible more root expansion to absorb moisture from deep layers, and also under high irrigation to absorb more K of that which may have moved down to the subsoil **El-Banna *et al.* (2001)** found that foliage fresh weight/plant increased with increasing irrigation water. **Kramer (1969)** studied the effect of water depletion and found that water deficit reduced plant growth. **Ali (1993)** found that potato plants subjected to water stress, had higher tuber dry matter percentage compared with plants irrigated frequently. **Stark *et al.* (1993)** reported that potato tuber dry weight decreased with increasing irrigation, while the weight of tops increased. **Sujatha and Krishnappa (1995) and El-Gamal (1985)** found that increasing K fertilization increased tuber dry matter content. **Sharme and Arodra (1992)** applied K up to levels equivalent to 53 kg K/f (124 kg K/ha) and obtained increased tuber dry matter with increased K rates. **Saha *et al.* (2001)** reported that tuber dry matter content were increased with increased application of K. **Abou Hussein**

(2005) applied up to 133 kg K/f and obtained increased growth of potato plants with increased rates of K. On the other hand **Buniak (1985)** reported that increasing K rate reduced dry matter content of potato tubers.

4.1.5. Total tubers yield per Faddan (Table 10 and Fig. 5):

Yield is expressed in megagrams per faddan (Mg/f), one megagram "Mg" $=10^6$ g; i.e. one metric ton. Yield of tubers as affect by G_1, G_2 and G_3 in absence of K was 5.242, 6.702 and 7.620 Mg/f respectively. Therefore G_2 and G_3 showed increases of 27.9 and 45.4 % respectively over G_1. Under conditions of K fertilization yields were generally greater. The lowest yield was 6.722 Mg/f (G_1 K_1 M_1) and the highest was 11.735 Mg/f (G_3 K_3 M_1).

I- Response to irrigation:

Main effect of irrigation treatments gave yields of 7.225, 9.260 and 10.541 Mg/f, due to G_1,G_2 and G_3 respectively. This indicates a superiority of G_2 and G_3 over G_1 amounting to 28.2 and 45.9 % respectively. Considering the interactions caused by K fertilization affecting the comparative response to irrigation, the G_2 and G_3 treatments were similar under conditions of the low K_1 rate particularly where K was applied in one dose; otherwise G_3 was superior to G_2. This shows that irrigation with more water was more affective when K was applied at a high rate and with split application.

II- Response to K - application:

All K-rates increased the yield as compared with the no K- treatment. There were increases in yield associated with increases in applied K. The main effect shows that K_3 gave the highest yield followed by K_2 then by K_1.The mean values of yield (Mg/f) were as follows: K_3 = 9.675 followed by K_2 = 9.096 then K_1 = 8.255. This indicates increases of 10.1 and 17.2 % for K_2 and K_3 respectively over K_1.

The superiority of K_3 over K_2 was particularly significant when the method of application was in split doses. This indicates that splitting is more effective when the rate of K application is high. Such an interaction caused by the method of application on the response to increased K rates indicates that when high K addition is practiced the first split dose, being high, enables plant roots to grow deeper; and with applying another split (second dose) the root system would continue growing and be able to remove more K from soil and increased the yield.

There was a 3-factor interaction affecting response of K application; i.e. an interaction involves the 3 factors of G, K, and M. Under irrigation with G_1, the medium and high rates of K_2 and K_3 were similar particularly where K was a applied as M_2, i.e. in one dose; however K_1 and K_2 were similar under

Table (10): Effect of irrigation scheduling treatments (G), potassium application method (M) and rate (K) on yield of fresh tubers Mg /f {Mg =megagram =1000 kg }(mean of 2 seasons).

K- application		Irrigation treatment (G)			
Method (M)	**Rate (K)**	G_1	G_2	G_3	**Mean**
M_1	K_1	6.722	8.619	8.849	**8.063**
	K_2	7.115	8.950	10.862	**8.976**
	K_3	7.375	10.072	11.735	**9.727**
Mean		7.071	9.213	10.482	**8.922**
M_2	K_1	7.022	8.452	9.870	**8.448**
	K_2	7.192	9.917	10.542	**9.217**
	K_3	7.925	9.554	11.388	**9.622**
Mean		7.380	9.307	10.600	**9.096**
Grand mean		7.225	9.260	10.541	**9.009**
Means of K treatments					
K_1		6.872	8.535	9.359	**8.255**
K_2		7.153	9.434	10.702	**9.096**
K_3		7.650	9.813	11.562	**9.675**
Treatments not receiving K					
		G_1	G_2	G_3	**Mean**
		5.242	6.702	7.620	**6.521**

L.S.D	at 0.05	at 0.01
G	0.125	0.168
K	0.125	0.168
M	0.102	0.137
GK	0.217	0.291
GM	0.177	0.237
MK	n.s	n.s
GKM	0.306	0.411

Notes :

Irrigation scheduling: evaporation pan coefficient (EF) as follows:

G_1: EF 0.8 (Long intervals)

G_2: EF 1.0 (Medium intervals)

G_3: EF 1.2 (Short intervals)

K_1, K_2 and K_3: 100, 133 and 166 kg K/f.

M_1; K applied in dose at with 1st irrigation.

M_2; K applied in 2 equal doses with 1st and 2nd irrigation.

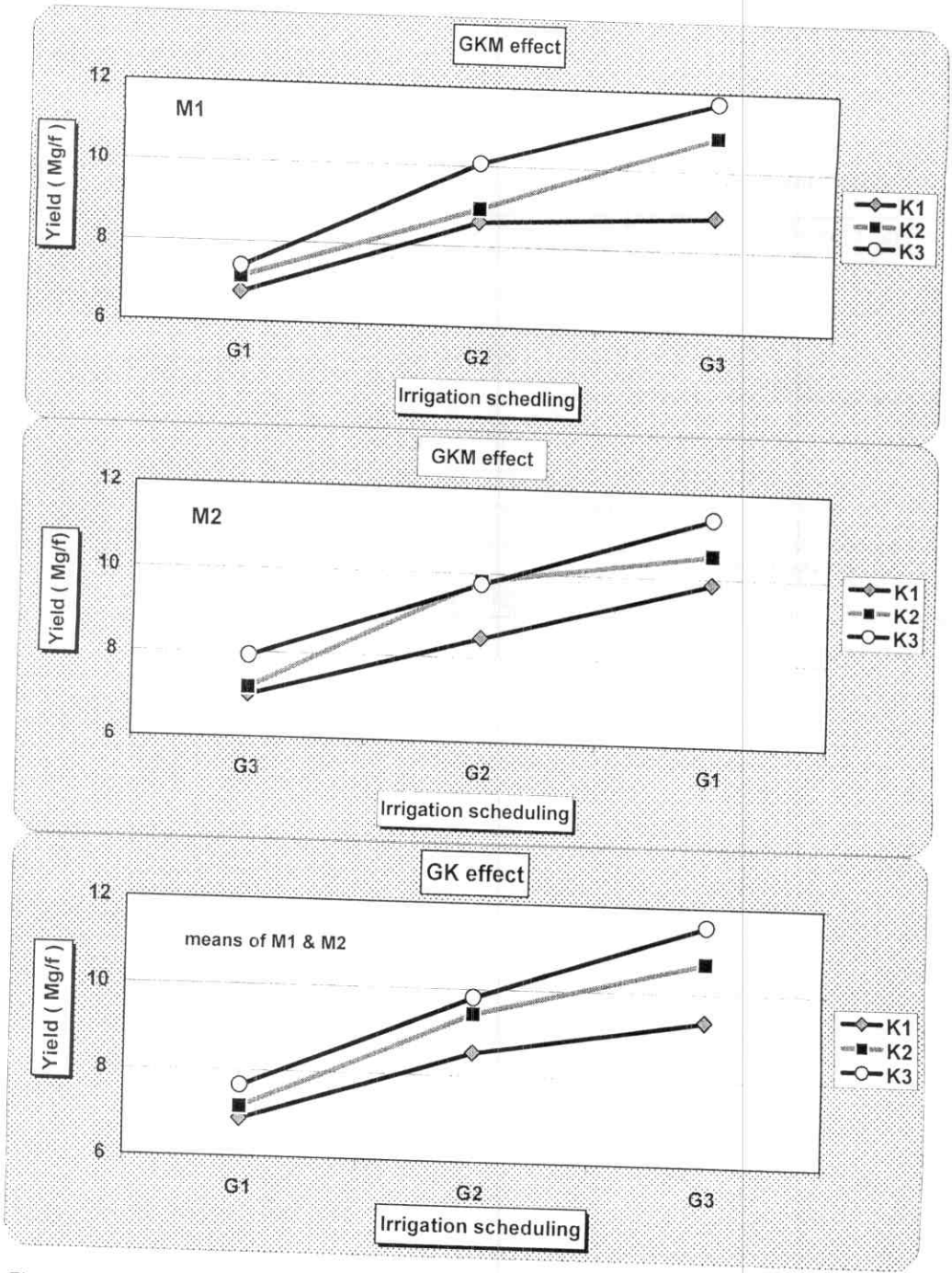

Figure (5): Effect of irrigation scheduling treatment of (G), potassium application method (M) and rate (K) on yield of fresh tubers (Mg/f).

Irrigation scheduling: evaporation pan coefficient (Ef) as follows:
G1: Ef 0.8 (Long intervals) G2: Ef 1.0 (Medium intervals) G3: Ef 1.2 (Short intervals)
K1, K2 and K3: 100, 133 and 166 kg K/f .
M1; K applied in dose at with 1st irrigation. M2; K applied in 2 equal doses with 1st and 2nd irrigation.