Journal

PHYSIOLOGICAL RESPONSE OF FODDER BEET PLANTS TO THE MUTUAL EFFECT AMONG IRRIGATION INTERVALS, POTASSIUM FERTILIZER AND GIBBERELLIC ACID SPRAY AT MARIUT REGION.

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J. Biol. Chem. Environ. Sci., 2010, Vol. 5(3):79-106
www.acepsag.org

ABSTRACT

Two field experiments were conducted during the two winter growing seasons of 2006 – 2007 and 2007 – 2008 at the experimental station of the Desert Research Center at Mariut, Alexandria Governorate, Egypt, to study the effect of irrigation interval (8, 16 and 24 days), potassium fertilizer (0, 100 and 150 kg K_2O/fed.) and gibberellic acid (tap water, 200 and 400 ppm) on growth, yield and chemical composition of fodder beet plants. The results could be summarized as follows:

1- Water stress by prolonging irrigation interval from 8 up to 24 days reduced top dry weight / plant, leaf area index, specific leaf weight (at 120 and 150 day from sowing), root diameter, fresh and dry weight of roots and leaves, fresh and dry yields of roots and leaves, crude protein, total carbohydrate and potassium in roots as well as total chlorophyll in leaves at 180 days from sowing. On the other hand, crude fiber, and sodium percentages in roots of fodder beet increased as the irrigation interval extended to 24 days at the first and second years.

2- Gibberellic spraying exerted a significant increase in leaves dry weight / plant, leaf area index, specific leaf weight, root diameter, fresh and dry weight of roots and top / plant, fresh and dry yields of roots and top / fed., crude protein, total carbohydrate, crude fiber and potassium in roots as well as total chlorophyll in leaves of fodder beet through the two seasons. Increasing gibberellic spraying levels from 0 up to 400 ppm decreased sodium

percentage in roots of fodder beet during 2006/2007 and 2007/2008 growing seasons.

3- Potassium application (150 kg K_2O/ fed.) increased top dry weight / plant, leaf area index, specific leaf weight, root diameter, fresh and dry weight of roots and top / plant, fresh and dry yields of roots and top / fed., crude protein, total carbohydrate and potassium in roots as well as total chlorophyll in leaves compared with control (nil potassium), these results were true through the first and second season. Sodium and crude fiber percentages in roots of fodder beet decreased with increasing potassium fertilizer from 0 up to 150 kg K_2O/ fed. through both seasons.

4- The mutual effect among irrigation interval, gibberellic acid (AG_3) and potassium fertilizer had a significant effect on root diameter, leaves / roots ratio, fresh and dry weight of top / plant, fresh yield of roots and top / fed. and crude protein percentage of fodder beet during 2006/2007 and 2007/2008 growing seasons.

Key words: Mariut region, Fodder beet, Irrigation interval, Gibberellic acid, Potassium fertilizer, Growth, yield, Chemical composition.

INTRODUCTION

Fodder beet (*Beta vulgaris,* L.) is the highest yielding forage crop any one can grow. The energy rich fodder beets are complementing the use of grass or protein rich legumes in the diet of the cattle. In many countries fodder beets serve as the reliable winter storage of feed. In other countries fodder beets play an important role in supplying forage in dry periods late in the summer. In nature, water is usually the most limiting factor for plant growth. This is also the case in home or commercial landscapes. If plants do not receive adequate rainfall or irrigation, the resulting drought stress can reduce growth more than all other environmental stresses combined.

Drought can be defined as the absence of rainfall or irrigation for a period of time sufficient to deplete soil moisture and injure plants. Drought stress occur when water loss from the plant exceeds the ability of the plant's roots to absorb water and when the plant's water content is reduced enough to interfere with normal plant processes. Using drought tolerant plants in the landscape can reduce the likelihood of plant injury due to drought stress. In this respect, Howell *et al*. (1987) indicated that prolnging irrigation interval from 3 to 7 weeks decreased growth and yield of sugar beet (*Beta vulgaris* L.) plants. Also, Sepaskhah and Kamgar-Haghighi (1997) mentioned that root yield of sugar beet decreased with increasing irrigation interval from 6 up to 10 days. In addition, Abdallah and Yassen (2008) found that extension irrigation interval from 14 up to 28 days decreased foliage fresh weight / plant, foliage dry weight and root diameter of fodder beet plants.

Gibberellic acid is a simple gibberellin, promoting growth and elongation of cells. It affects decomposition of plants and helps plants grow if used by small amounts, but eventually plants develop tolerance for it. Gibberellic acid stimulates the cells of germinating seeds to produce mRNA molecules that code for hydrolytic enzymes. Also, gibberellic acid is a very potent hormone whose natural occurrence in plants controls their development. Since GA3 regulates growth, applications of very low concentrations can have a profound effect while too much will have the opposite effect. It is usually used in concentrations between 0.01-1.0 mg/L. In this respect, Bora and Sarma (2006) on pea, reported that increasing gibberellic acid (GA3) from 10 to 1000 µg m/L increased growth and yield characters. Ibrahim et al. (2007) studied the effect of some bioregulators (GA3 , IAA, benzyl adenine at the rate of 100 ppm or growth retardant ancymidol at the rate of 100 ppm) on growth, yield and its components, photosynthetic pigments, mineral ions contents as well as the seed yield quality (represented by total carbohydrate and protein contents) of Vicia faba L. They found that application of all the used treatments led to significant changes in the following items: plant height, average number of leaves, leaf area per plant and the dry weight of the shoot. However, Aman et al. (2009) on groundnut, pointed out that some of the plant growth regulators (Brassinolides, triacontanol, GA3, and NAA) were effective significantly in inducing enhanced pod yield, number of pods per plant, pod weight per plant and shelling percentage. They refered also that, in the plants treated with triacontanol and GA3, the total number of flowers produced per plant was increased. Islam et al. (2010) on Vigna mungo L. mentioned that increasing spray with GABA (a mixture of GA3 and ABA) from 0.25 to 1.0 mg/L increased plant height, number of branches per plant, number of leaves per plant, total chlorophyll content, number of pods per plant, pod length, number of seeds per pod and seed yield compared by the control (fresh water).

Potassium plays an important role in the growth and development of plants, as activates enzymes, maintains cell turgor, enhances photosynthesis, reduces respiration, helps transport sugars and starches, aids in nitrogen uptake and is essential for protein synthesis. In addition, to plant metabolism, potassium improves crop quality because it extends the grain filling period, helps with grain filling and kernel weight, strengthens straw, increases disease resistance, and helps the plant better withstand stress. Some investigators found that potassium fertilizer increased growth, yield of *Beta vulgaris* L., among whom Milford *et al.* (2000) who mentioned that increasing potassium fertilizer from 0 up to 600 kg K/ha. increased root yield of sugar beet. Also, Abdel-Mawly and Zanouny (2004) reported that total root yield and top yield of sugar beet plants increased as K fertilizer increased. Romer *et al.* (2004) showed that root yield of sugar beet increased with increasing potassium fertilizer from 0 up to 524 kg K / ha. In addition, Abd El-Lateef (2009) found that raising potassium concentration added as spraying or soil application caused gradually increasing in root length, root diameter, fresh and dry weight of roots and tops / plant, leaf area, fresh and dry yield of roots and tops/ fed., crude protein, total carbohydrate, nitrogen and potassium content of fodder beet plants.

The aim of this study was to evaluate the effect of three irrigation intervals i.e. 8, 16 and 24 days, three levels of potassium fertilizer (0, 100 and 150 K_2O / fed.) and three levels of gibberellic acid (tap water, 200 and 400 ppm) on growth, yield and chemical composition of fodder beet (*Beta vulgaris* L.) grown in calcareous soil at Mariut region.

MATERIALS AND METHODS

Two field experiments were conducted during the two winter growing years of 2006 – 2007 and 2007 – 2008 at the experimental station of Desert Research Center at Mariut, Alexandria Governorate, Egypt, to study the effect of irrigation intervals, potassium fertilizer and gibberellic acid on growth, yield and chemical composition of fodder beet (*Beta vulgaris* L.). The soil of this farm is sandy clay loam in texture and calcareous in nature. The physical and chemical properties of the experiment soil at the depth of 0-30 and 30-60 cm, were determined according the methods described by Piper (1950) and Jackson (1958) respectively. The results of these determinations are shown in Tables (1 and 2). The following factors were used:

A- Irrigation intervals

By using three irrigation intervals (8, 16 and 24 days) Flooding irrigation system was used.

B- Gibberellic acid (GA_3)

1- Tap water (control)2- 200 ppm (0.2 g/L.)3- 400 ppm(0.4 g/L.)

C- Potassium fertilizer rates

1- Control (without fertilizer) 2- 100 kg K_2O / fed. 3- 150 kg K_2O / fed.

Each potassium level splited two equal doses the first dose was added after 30 days from sowing and the second one at 45 days from sowing, potassium was added in the form of potassium sulfate (48%K2O).

Twenty seven of treatments were arranged in split split plot design (S.S.P.D.) with four replicates according to Gomez and Gomez (1984). The main plots were devoted to the irrigation interval; the sub-plots were occupied by the gibberellic acid while the sub-sub plots were assigned for potassium fertilizer.

All the experimental plots were received 20 m^3 organic manure (sheep dung) and 300 kg calcium superphosphate (15.5% P_2O_5)/feddan as a basal application during preparation the soil; i.e. before seed sowing. Also, 200 kg ammonium sulphate (20.5% NH_4SO_4) and potassium sulphate (48-50% K_2O) was side dressed at the rate of 150 kg/feddan, These chemical fertilizers were divided into two equal parts and applied after one and two months from sowing in each season.

Fodder beet seeds were sown on October 15th in the first and second seasons. The experimental plot area 10.5 m^2 (3 x 3.5 m), consisting of 6 ridges, each of 50 cm width and 3.5 m length, 50 cm were between hills and four seeds were planted in each hill. Regular irrigation was carried out for the whole experiment, one week from sowing. Analysis of irrigation water were given in Table (3).

Data recorded were as follows:

A- Growth characters

Five plants were taken at random from the middle rows of each sub-plot. Plant Samples were taken after 120 and 150 days from sowing date. The samples were carefully uprooted and the following data were recorded for each sample:-

1- Top dry weight / plant
2- Leaf area index (LAI). It was calculated by using the following equation

$$LAI = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Plant ground area (cm}^2\text{)}}$$

3- Specific leaf weight (SLW)

$$SLW\ (mg/cm^2) = \frac{\text{Leaf dry weight (mg)}}{\text{Leaf area per plant (cm}^2\text{)}}$$

B- Yield characters

The plants grown in three middle rows were harvested after 180 days after sowing from the of each plot to record the following data:

1- Root diameter (cm) / plant
2- Top / roots ratio
3- Fresh and dry weights of roots and top / plant
4- Fresh and dry yields of roots and top (ton /fed.)

C- Chemical composition

Chemical composition was determined in roots at 180 days from sowing date. Total nitrogen was determined by using micro-Kjeldahl method as described by Peach and Tracey (1956). Crude protein was calculated by multiplying total nitrogen by 6.25. Total carbohydrates were estimated calorimetrically applying the phenol sulphuric acid method as adopted by Dubois *et al*. (1951). Values were expressed as g/100g dry wt. Crude fiber was determined by using the method described in A.O.A.C. (1970). Sodium and potassium were measured by flame photometer as described by Irri (1976). The total chlorophyl content was determined in the leaf as percentage by Aminota SPAD chlorophyll meter (model SPAD520) according to Yadava, (1986).

All data were statistically analysed according to Snedecor and Cochran (1967). The differences between means were tested by L.S.D. at 5% level (Steel 1960).

Table (1): Mechanical properties of the experimental soil.

Depth (cm)	Particle size distribution (%)				Soil texture
	Coarse sand	Fine sand	Silt	Clay	
0-30	3.12	4916	18.90	28.82	Sandy clay loam
30-60	2.66	50.02	20.28	27.04	Sandy clay loam

Table (2): Chemical properties of the experimental soil.

Depth (cm)	pH	Ec (dS/m)	Saturation soluble extract							
			Soluble anions (meq / L)				Soluble cations (meq / L)			
			Co^-_3	HCO^-_3	SO^-_4	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
0-30	7.8	4.30	-	4.37	17.73	16.67	8.85	6.32	22.90	0.70
30-60	7.9	3.60	-	1.76	14.00	15.50	5.95	3.01	21.70	0.60

Table (3): Chemical analysis of the irrigation water of Mariut research station.

pH	EC (dS/m)	Soluble anions (meg/l)				Soluble cations (meg/l)			
		Ca^-_3	Hco^-_3	So^-_4	Cl^-	Ca^{++}	Mg^{++}	Na^+	K^+
7.30	3.43	0.00	8.74	8.30	16.56	6.44	7.76	18.26	1.14

RESULTS AND DISCUSSION

A-Effect of each of the applied individual factors (irrigation interval, gibberellic acid and potassium fertilizer)

1-Growth characters and yield:

It is clear from results presented in Tables (4, 5 and 6) that prolonging irrigation interval from 8 up to 24 days had a significant decrease on top dry weight, leaf area index, specific leaf weight at 120 and 150 day from sowing (Table 4), and the same effect was observed also on root diameter, top / roots ratio, fresh and dry weight of roots and top (Table 5), fresh and dry yields of roots and top at 180 days from sowing during 2006/2007 and 2007/2008 took the same trend in their response to irrigation intervals (Table 6). The reduction in growth and yield characters as a result of prolonging irrigation interval might be due to water stress, which is caused by insufficient soil moisture, is among the chief causes of poor growth or poor health in plants. It is responsible for slow growth and, in severe cases, dieback of stems. It also makes plants more susceptible to disease and less tolerant of insect feeding. Similar results were obtained by Sepaskhah and Kamgar- Haghighi (1997), Mirzali *et al.* (2005) and Abdallah and Yassen (2008)

Also, data presented in Tables (4, 5 and 6) showed that growth and yield characters of fodder beet were significantly affected by gibberellic application during both years. Gibberellic application at the concentration of 400 ppm increased top dry weight, leaf area index and specific leaf weight at 120 and 150 day after sowing (Table 4), root diameter, fresh and dry weight of roots and top / plant (Table 5), fresh and dry yields of roots and top / fed. at 180 days after sowing (Table 6) comprised with control (tap water), these results were obtained through both seasons. The increasing in growth and yield may be due to gibberellins stimulate growth in the roots and leaves. Inside the roots the gibberellins stimulate cell division and cell elongation. Many researchers mentioned the importance role of gibberellins in plants. In this regard, Ibrahim *et al.* (2007) on *Vicia faba* L., Aman *et al.* (2009) on groundnut and Islam *et al.* (2010) on *Vigna mungo* L.

In addition, the data recorded in Tables (4, 5 and 6) illustrated that increasing potassium rates from 0 up to 150 kg K_2O / fed. to fodder beet plants under Mariut conditions exerted a statistical significant increase in top dry weight, leaf area index, specific leaf weight (Table 4), root diameter, top / roots ratio, fresh and dry weight of roots and top (Table 5), fresh and dry yields of roots and top (Table 6). Such effect was true in both seasons. The increases in growth and yield may be attributed to adequacy of potassium applied at soil and this turn favoures the absorption of different minerals and consequently caused an increase in the amount of metabolites synthesized by the plants. Supporting results were obtained by Milford *et al.* (2000), Abd El-Mawly and Zanouny (2004) and Vijay *et al.* (2009).

Table (4): Effect of irrigation interval, gibberellic acid and potassium fertilizer on leaves dry weight, leaf area index and specific leaf weight of fodder beet plants at 120 and 150 day from sowing during winter season of 2006/2007 and 2007/2008.

Seasons		2006/2007		2007/2008		2006/2007		2007/2008		2006/2007		2007/2008	
Characters		Toip dry weight (g)				leaf area index				specific leaf weight (mg/cm^2)			
Treatments		120 days	150 days	120 days	150 days	120 days	150 days	120 days	150 days	120 days	150 days	120 days	150 days
Irrigation	8 days	49.74	77.15	43.22	65.89	4.61	5.18	4.292	4.811	10.73	14.88	10.00	14.18
	16 days	43.56	70.30	38.44	61.22	4.47	4.96	3.813	4.651	9.69	14.13	10.00	14.07
	24 days	37.52	58.67	31.56	51.89	4.00	4.50	3.611	4.168	9.34	12.99	8.63	13.03
L.S.D. at 5%		**1.48**	**0.67**	**0.63**	**4.65**	**0.10**	**0.01**	**0.022**	**0.010**	**0.25**	**0.10**	**0.14**	**0.84**
Gabbrlic	Tap water	36.22	63.37	32.00	53.44	4.217	4.686	3.713	4.325	8.51	13.46	8.538	12.97
	200 ppm	43.70	67.81	37.33	60.11	4.365	4.911	3.913	4.558	9.981	13.75	9.45	13.88
	400 ppm	50.89	74.93	43.89	65.44	4.495	5.048	4.091	4.747	11.26	14.79	10.64	14.43
L.S.D. at 5%		**0.75**	**0.68**	**0.55**	**2.84**	**0.07**	**0.01**	**0.024**	**0.018**	**0.22**	**0.17**	**0.14**	**0.24**
Potassium	Control	37.48	63.30	31.11	53.11	4.03	4.52	3.644	4.159	8.93	12.85	8.466	12.71
	100 kg / fed	43.48	65.67	38.00	58.33	4.16	4.61	3.655	4.292	9.77	13.67	9.519	13.31
	150 kg /fed.	44.52	68.70	39.44	60.33	4.37	4.94	3.939	4.639	9.90	13.85	9.561	13.73
L.S.D. at 5%		**0.66**	**0.56**	**0.54**	**3.66**	**0.07**	**0.01**	**0.025**	**0.039**	**0.17**	**0.13**	**0.15**	**0.25**

Table (5): Effect of irrigation interval, gibberellic acid and potassium fertilizer on root diameter, leaves / roots ratio and fresh and dry weight of roots and leaves of fodder beet plants at 180 days from sowing during winter season of 2006/2007 and 2007/2008.

Seasons		2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008
Characters / Treatments		Root diameter (cm)		Top / roots ratio		Root fresh weight (g) / plant		Root dry weight (g) / plant		Top fresh weight (g) / plant		Top dry weight (g) / plant	
Irrigation	8 days	12.97	12.01	0.243	0.252	1165.89	1028.00	266.56	227.10	518.04	473.40	64.56	56.44
	16 days	12.24	11.35	0.255	0.270	1086.33	855.10	243.37	186.70	507.93	428.00	61.33	49.78
	24 days	11.32	10.77	0.227	0.262	977.11	766.00	214.26	164.80	423.93	379.90	48.89	42.67
L.S.D. at 5%		**0.08**	**0.06**	**0.013**	**0.002**	**6.46**	**50.11**	**1.22**	**7.63**	**2.33**	**10.40**	**0.252**	**0.63**
Gabbrlic	Tap water	11.63	10.83	0.251	0.264	1002.00	799.40	220.80	172.60	470.20	399.10	55.56	45.11
	200 ppm	12.20	11.42	0.232	0.266	1071.00	859.60	239.40	187.40	462.20	423.60	55.78	49.11
	400 ppm	12.70	11.89	0.241	0.253	1156.00	990.60	264.00	218.60	517.50	458.70	63.44	54.67
L.S.D. at 5%		**0.04**	**0.03**	**0.027**	**0.011**	**5.29**	**19.59**	**1.38**	**6.38**	**4.39**	**6.85**	**0.547**	**0.58**
Potassium	Control	11.07	10.54	0.249	0.270	971.44	777.70	211.37	167.20	447.48	391.40	52.78	44.56
	100 kg / fed	11.49	10.70	0.215	0.227	1027.11	863.00	234.78	190.60	463.59	405.10	56.78	47.89
	150 kg /fed.	12.50	11.52	0.233	0.259	1100.89	892.80	248.33	195.10	480.74	431.60	58.00	50.11
L.S.D. at 5%		**0.04**	**0.04**	**0.027**	**0.005**	**7.32**	**15.06**	**1.86**	**3.52**	**4.77**	**3.15**	**0.542**	**0.46**

Table (6): Effect of irrigation interval, gibberellic acid and potassium fertilizer on fresh and dry yields of roots and leaves of fodder beet plants at 180 days from sowing during winter season of 2006/2007 and 2007/2008.

Seasons		2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008
Characters / Treatments		Root fresh yield (Ton / fed.)		Root dry yield (Ton / fed.)		Top fresh yield (Ton / fed.)		Top dry yield (Ton / fed.)	
Irrigation	8 days	48.967	43.192	11.195	9.540	21.758	19.882	2.711	2.364
	16 days	45.626	35.914	10.222	7.839	21.333	17.980	2.576	2.087
	24 days	41.039	32.173	8.999	6.920	17.805	15.960	2.053	1.793
L.S.D. at 5%		**0.316**	**2.157**	**0.050**	**0.329**	**0.179**	**0.437**	**0.027**	**0.026**
Gabbrlic	Tap water	42.092	33.582	9.274	7.250	19.753	16.763	2.333	1.888
	200 ppm	44.980	36.100	10.06	7.873	19.412	17.792	2.343	2.061
	400 ppm	48.561	41.643	11.09	9.176	21.730	19.261	2.665	2.295
L.S.D. at 5%		**0.181**	**0.818**	**0.057**	**0.269**	**0.208**	**0.288**	**0.027**	**0.025**
Potassium	Control	40.801	32.660	8.878	7.029	18.794	16.441	2.217	1.863
	100 kg / fed	43.139	36.253	9.861	7.997	19.471	17.013	2.385	2.012
	150 kg /fed.	46.237	37.501	10.430	8.195	20.191	18.132	2.436	2.104
L.S.D. at 5%		**0.029**	**0.633**	**0.078**	**0.149**	**0.287**	**0.132**	**0.023**	**0.021**

2- Chemical composition:

Results in Table (7) revealed that crude protein percentage, total carbohydrate percentage, potassium content in roots and total chlorophyll in leaves of fodder beet were significantly decreased by increasing irrigation interval from 8 up to 24 days during 2006/2007 and 2007/2008 seasons. On the contrary, crude fiber percentage and sodium were increased by increasing irrigation intervals in two experimentation years. The depression in protein content may be due to disturbance in energy metabolism in plants grown under the longest irrigation interval. These results are in agreement with those obtained by Abdallah and Yassen (2008) on Fodder beet.

Also, results in Table (7) indicated also that by increasing gibberellic spraying from 0 up to 400 ppm, crude protein, total carbohydrate, crude fiber, potassium content in roots and total chlorophyll in leaves of fodder beet were significantly increased in both years, while sodium content significantly decreased with increasing gibberellic acid up to 400 ppm in the first and second years. These findings are in agreement with those obtained by Ibrahim *et al.* (2007) and Islam *et al.* (2010)

The same Table showed that all chemical components under study i.e. crude protein, total carbohydrate, crude fiber, potassium and sodium content in roots and total chlorophyll in leaves of fodder beet were significantly responded to potassium fertilizer application in two experimentation years. Increasing potassium fertilizer application from 0 up to 150 kg K_2O / fed. increased crude protein, total carbohydrate and potassium content in roots as well as total chlorophyll in leaves with the first and second season. On the contrary, control treatment (nil potassium treatment) gave the highest crude fiber and sodium content as compared with all the other fertilizer treatments during both seasons. Similar results were obtained by Ahmed (1997) who mentioned that raising potassium application caused gradual increasing in crude protein and total carbohydrate of fodder beet plants. In addition, Abd El-Lateef (2009) reported that increasing potassium fertilizer increased crude protein, total carbohydrate, nitrogen and potassium content of fodder beet plants.

Table (7): Effect of irrigation interval, gibberellic acid and potassium fertilizer on crude protein, total carbohydrate, crude fiber, potassium and sodium in roots as well as total chlorophyll in leaves of fodder beet plants at 180 days from sowing during winter season of 2006/2007 and 2007/2008.

Seasons		2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008
Characters / Treatments		Crude protein %		Total carbohydrate %		Crude fiber %		Total chlorophyll (mg \100g)		Potassium %		Sodium %	
Irrigation	8 days	11.32	10.11	57.11	54.56	12.47	13.96	35.27	33.29	3.12	2.76	0.77	0.91
	16 days	10.66	9.78	56.09	54.11	12.72	14.76	34.83	32.56	2.76	2.54	0.96	1.11
	24 days	9.88	9.52	53.24	53.54	13.15	15.56	34.33	32.21	2.51	2.27	1.13	1.31
L.S.D. at 5%		**0.01**	**0.02**	**0.02**	**0.06**	**0.03**	**0.13**	**0.09**	**0.06**	**0.03**	**0.02**	**0.08**	**0.06**
Gabbrlic	Tap water	10.25	9.52	52.87	53.72	12.36	14.17	34.49	32.43	2.58	2.34	1.13	1.27
	200 ppm	10.67	9.85	56.55	54.01	12.79	14.79	34.80	32.72	2.78	2.52	0.92	1.09
	400 ppm	10.94	10.05	57.02	54.48	13.19	15.32	35.15	32.91	3.04	2.71	0.81	0.98
L.S.D. at 5%		**0.04**	**0.03**	**0.02**	**0.03**	**0.02**	**0.10**	**0.10**	**0.04**	**0.02**	**0.02**	**0.05**	**0.02**
Potassium	Control	9.71	9.56	50.66	48.32	13.09	15.07	31.30	29.26	2.37	2.23	1.07	1.22
	100 kg / fed	10.22	8.91	53.26	53.75	12.80	14.78	34.37	32.39	2.80	2.44	0.93	1.11
	150 kg /fed.	10.68	9.82	56.16	54.1	11.15	12.99	34.83	32.72	2.85	2.58	0.77	0.89
L.S.D. at 5%		**0.03**	**0.03**	**0.02**	**0.03**	**0.03**	**0.11**	**0.07**	**0.03**	**0.02**	**0.02**	**0.02**	**0.02**

B- Effect of the mutual effect between: (Irrigation intervals x Gibberellic acid, Irrigation intervals x Potassium and Gibberellic acid x Potassium)

1- Growth characters and yield:

It is clear from data in Table (8) that the mutual effect between the irrigation intervals and gibberellic acid on top dry weight / plant, leaf area index and specific leaf weight of fodder beet at 120 and 150 day from sowing were significant through both seasons except top dry weight after 150 days and leaf area index after 120 days during the first season. The highest mean values were obtained with irrigation every 8 days and sprayed with 400 ppm gibberellic acid at 120 and 150 days from sowing with the two seasons.

Top dry weight and leaf area index of fodder beet were significantly affected by the interaction between irrigation intervals and potassium fertilizer at 120 and 150 day from sowing at the second season only, while this interaction had a significant effect on specific leaf weight at 120 and 150 day from sowing at the first season only. Irrigation every 8 days and 150 kg K_2O/fed. gave the highest values of top dry weight, leaf area index and specific leaf weight of fodder beet at 120 and 150 day from sowing through both seasons. Similar results were reported by Mazher *et al.* (2007) and Bajehbaj *et al.* (2009).

Top dry weight / plant was significantly affected by the interaction between gibberellic acid and potassium fertilizer at 120 and 150 day during the second season and at 120 day at the first one. The highest value of top dry weight, leaf area index and specific leaf weight were obtained when gibberellic acid and potassium fertilizer were added at the highest rate of 400 ppm and 150 kg K_2O / fed., respectively.

Data reported in Table (9) indicate that the interaction between irrigation intervals and gibberellic acid had a significant effect on root diameter and fresh weight of roots and top / plant of fodder beet with 2006/2007 and 2007/2008 seasons, while such interaction had a significant effect on top/roots ratio and roots and top dry weights at the first season only. Spraying with 400 ppm gibberellic acid under irrigation every 8 days gave the highest value of growth parameters through the two seasons. As for the interaction between irrigation intervals and potassium fertilizer, there were a significant effect on root diameter, top / roots ratio, fresh and dry weight of roots / plant of fodder beet by the two seasons, but fresh and dry weights of top per plant were significantly responded to that interaction at the second season only. Irrigation every 8 days and fertilized by 150 kg K_2O / fed. produced the highest values of growth characters through both seasons compared with those of other interaction factors.

Table (8): Effect of the first order interactions on top dry weight, leaf area index and specific leaf weight of fodder beet plants at 120 and 150 day from sowing during winter seasons 2006/2007 and 2007/2008.

Seasons		2006 / 2007		2007 / 2008		2006/ 2007		2007/ 2008		2006 / 2007		2007 / 2008	
Characters		leaves dry weight (g)				leaf area index				specific leaf weight (mg/cm^2)			
Irrigation intervals (days)		Days from sowing date				Days from sowing date				Days from sowing date			
		120	150	120	150	120	150	120	150	120	150	120	150
Irrigation intervals x gibberellic acid (ppm)													
8 days	T.W	43.22	71.11	36.00	57.33	4.45	4.99	4.13	4.56	9.69	14.25	8.68	12.95
	200	49.22	76.67	43.67	67.33	4.61	5.20	4.34	4.83	10.66	14.74	10.02	14.44
	400	56.78	83.67	50.00	73.00	4.78	5.35	4.41	5.04	11.83	15.64	11.30	15.14
16 days	T.W	36.00	65.33	35.67	56.33	4.31	4.77	3.59	4.46	8.31	13.68	9.89	13.57
	200	43.22	68.78	36.00	61.33	4.48	5.01	3.82	4.67	9.61	13.72	9.35	14.14
	400	51.44	76.78	43.67	66.00	4.60	5.11	4.03	4.82	11.14	14.99	10.77	14.49
24 days	T.W	29.44	53.67	24.33	46.67	3.89	4.30	3.42	3.95	7.53	12.46	7.05	12.38
	200	38.67	58.00	32.33	51.67	4.00	4.53	3.58	4.18	9.67	12.78	8.98	13.05
	400	44.44	64.33	38.00	57.33	4.10	4.68	3.84	4.37	10.81	13.74	9.86	13.66
L.S.D. at 5%		1.31	N.S	0.95	4.92	N.S	0.01	0.04	0.03	0.38	0.29	0.24	0.16
Irrigation intervals x potassium (kg K_2O/fed)													
8 days	Con.	43.78	72.44	36.33	59.00	4.40	4.82	4.05	4.34	9.92	15.00	8.94	13.88
	100	50.11	76.67	43.67	66.67	4.64	5.28	4.33	4.96	10.77	14.50	10.04	14.04
	150	55.33	82.33	49.67	72.00	4.80	5.43	4.49	5.13	11.50	15.13	11.02	14.61
16 days	Con.	36.89	64.11	31.33	54.00	4.26	4.73	3.52	4.18	8.63	13.55	8.88	13.72
	100	43.56	70.44	39.00	62.00	4.47	4.99	3.86	4.78	9.72	14.08	10.07	13.96
	150	50.22	76.33	45.00	67.67	4.67	5.17	4.06	4.99	10.71	14.75	11.06	14.52
24 days	Con.	31.78	53.33	25.67	46.33	3.83	4.27	3.36	3.96	8.25	12.47	7.58	12.33
	100	36.78	59.00	31.33	52.33	4.01	4.54	3.63	4.17	9.21	12.97	8.57	13.18
	150	44.00	63.67	37.67	57.00	4.16	4.70	3.85	4.38	10.55	13.54	9.74	13.58
L.S.D. at 5%		N.S	1.00	0.96	6.81	N.S	0.02	0.04	0.07	0.30	0.23	N.S	N.S
Gibberellic acid x potassium(kg K_2O/fed)													
T.W	Con.	30.89	58.78	26.33	47.00	4.01	4.45	3.47	3.96	7.64	13.15	7.54	12.46
	100	36.33	62.67	32.00	54.00	4.24	4.74	3.75	4.43	8.51	13.20	8.50	12.91
	150	41.44	68.67	37.67	59.33	4.40	4.88	3.92	4.59	9.38	14.04	9.57	13.55
200	Con.	37.56	62	30.67	53.33	4.16	4.63	3.66	4.15	8.99	13.35	8.32	13.38
	100	43.67	68.11	37.33	61.00	4.38	4.99	3.93	4.67	10.01	13.60	9.44	13.91
	150	49.89	73.33	44.00	66.00	4.56	5.11	4.14	4.86	10.95	14.30	10.59	14.34
400	Con.	44.00	69.11	36.33	59.00	4.32	4.74	3.80	4.37	10.17	14.52	9.53	14.09
	100	50.44	75.33	44.67	66.00	4.50	5.09	4.14	4.83	11.18	14.75	10.75	14.37
	150	58.22	80.33	50.67	71.33	4.67	5.31	4.34	5.05	12.43	15.09	11.65	14.83
L.S.D. at 5%		0.61	N.S	1.01	6.81	N.S	0.02	0.04	N.S	N.S	0.23	N.S	N.S

T.W. = Tap water
Con. = Control

Table (9): Effect of the first order interactions on root diameter, top / roots ratio and fresh and dry weight of roots and top of fodder beet plants at 180 days from sowing during winter seasons 2006/2007 and 2007/2008.

Irrigation intervals (days)		Root diameter (cm)		Top / roots ratio		Root fresh weight (g) / plant		Root dry weight (g) /plant		Top fresh weight (g) / plant		Top dry weight (g) / plant	
		2006/2007	2007/2008	2006/2007	2007/2008	2006/2007	2007/2008	2006/2007	2007/2008	2006/2007	2007/2008	2006/2007	2007/2008
Irrigation intervals x gibberellic acid (ppm)													
8 days	T.W	12.31	11.57	0.240	0.259	1086.33	919.30	243.22	201.00	475.67	441.30	58.33	51.67
	200	13.03	12.05	0.241	0.258	1157.00	1003.00	264.33	221.30	511.44	474.70	63.67	56.00
	400	13.56	12.42	0.247	0.239	1254.33	1163.00	292.11	259.00	567.00	504.30	71.67	61.67
16 days	T.W	11.79	10.71	0.295	0.271	1015.00	777.00	222.56	168.00	550.78	399.30	65.33	45.00
	200	12.29	11.40	0.235	0.279	1078.67	823.70	241.11	179.30	468.67	427.00	56.67	49.67
	400	12.62	11.93	0.233	0.260	1165.33	964.70	266.44	212.70	504.33	457.70	62.00	54.67
24 days	T.W	10.79	10.20	0.219	0.263	905.00	702.00	196.67	148.70	384.11	356.70	43.00	38.67
	200	11.28	10.80	0.221	0.260	977.33	752.30	212.78	161.70	406.56	369.00	47.00	41.67
	400	11.90	11.32	0.243	0.261	1049.00	843.70	233.33	184.00	481.11	414.00	56.67	47.67
L.S.D. at 5%		**0.24**	**0.06**	**0.047**	**N.S**	**9.00**	**33.95**	**2.40**	**N.S**	**7.62**	**11.87**	**0.95**	**N.S**
Irrigation intervals x potassium (kg K_2O/fed)													
8 days	Con.	11.69	11.08	0.254	0.259	1048.00	900.30	232.78	196.30	484.00	429.00	59.33	50.00
	100	13.31	12.19	0.234	0.251	1194.67	104500	274.78	231.00	516.33	481.30	64.33	57.33
	150	13.91	12.78	0.240	0.246	1255.00	1140.00	292.11	254.00	553.78	510.00	70.00	62.00
16 days	Con.	11.12	10.52	0.265	0.282	967.67	747.00	210.78	160.30	467.67	394.00	55.33	45.00
	100	12.64	11.48	0.245	0.271	1119.00	860.70	251.89	188.00	506.89	434.30	61.33	50.67
	150	12.95	12.04	0.253	0.257	1172.33	957.70	267.44	211.70	549.22	455.70	67.33	53.67
24 days	Con.	10.41	10.01	0.229	0.269	898.67	685.70	190.56	145.00	390.78	351.30	43.67	38.67
	100	11.54	10.90	0.221	0.256	989.00	772.30	218.33	166.30	419.00	379.00	48.33	42.33
	150	12.02	11.42	0.233	0.260	1043.67	840.00	233.89	183.00	462.00	409.30	54.67	47.00
L.S.D. at 5%		**0.08**	**0.07**	**0.047**	**0.008**	**12.00**	**26.62**	**3.29**	**40.57**	**N.S**	**5.86**	**N.S**	**0.82**
Gibberellic acid x potassium(kg K_2O/fed)													
T.W	Con.	10.67	10.14	0.266	0.272	897.67	702.67	190.11	148.67	438.67	366.33	50.67	40
	100	11.89	10.85	0.238	0.261	1026.67	810.00	228.56	175.33	462.67	402.00	54.67	45.67
	150	12.33	11.50	0.250	0.260	1082.00	885.67	243.78	193.67	509.22	429.00	61.33	49.67
200	Con.	11.07	10.50	0.231	0.274	974.00	748.00	211.67	160.67	415.44	382.33	49.00	43.67
	100	12.53	11.60	0.228	0.261	1090.00	878.00	244.78	191.33	463.11	427.67	56.00	49.33
	150	13.00	12.16	0.238	0.262	1149.00	952.67	261.78	210.33	508.11	460.67	62.33	54.33
400	Con.	11.49	10.97	0.252	0.263	1042.67	882.33	232.33	192.33	488.33	425.67	58.67	50.00
	100	13.06	12.12	0.234	0.256	1186.00	990.33	271.67	218.67	516.44	465.00	63.33	55.33
	150	13.54	12.58	0.238	0.241	1240.00	1099.00	287.89	244.67	547.67	485.33	68.33	58.67
L.S.D. at 5%		**0.08**	**0.01**	**0.047**	**N.S**	**12.00**	**N.S**	**N.S**	**N.S**	**8.43**	**5.86**	**0.96**	**0.82**

The interaction between gibberellic acid application and potassium fertilizer rates had a significant effect on fresh and dry weights of top /plant and root diameter of fodder beet during both seasons. Whereas, such effect was observed also on top/roots ratio and root fresh weight / plant at the first season only. The maximum values of the most growth characters through both seasons were obtained by using 400 ppm gibberellic acid and adding 150 kg K2O/ fed.

Results presented in Table (10) showed clearly that the mutual effect between irrigation intervals and gibberellic acid had a significant effect on root fresh yield in 2006/2007 and 2007/2008 seasons. Whereas, the rest yield studied yield characters i.e. root dry yield and fresh and dry yield of top were responded significantly to this interaction at the first season only. The maximum values were obtained by irrigation interval every 8 days with 400 ppm gibberellic acid for fresh and dry yields of roots and top of fodder beet plant through the first and second seasons.

The interaction between irrigation intervals and potassium fertilizer rates had a significant effect on fresh and dry yield of roots through the two growing seasons, while yield of fresh and dry top were significantly responded to this interaction in the second year only. The highest values of fresh and dry yield of roots and top were obtained at 8 days with 150 kg K_2O/ fed. at both seasons.

The effect of interaction between gibberellic acid and potassium on fresh and dry yields of top of fodder beet was significant with the first and second season, also this interaction had a significant effect on root fresh yield at the first season only, gibberellic acid sprayed at 400 ppm with 150 kg K_2O/ fed. for fresh and dry yields of roots and top produced the highest values through the both seasons.

Table (10): Effect of the first order interactions on fresh and dry yields of roots and top of fodder beet plants at 180 days from sowing during winter seasons 2006/2007 and 2007/2008.

Irrigation intervals (days)		2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008	2006/ 2007	2007/ 2008
		Root fresh yield Ton / fed.		Root dry yield Ton / fed.		Top fresh yield Ton / fed.		Top dry yield Ton / fed.	
Irrigation intervals x gibberellic acid (ppm)									
8 days	T.W	45.626	38.612	10.215	8.452	19.978	18.536	2.450	2.157
	200	48.594	42.112	11.102	9.297	21.481	19.936	2.674	2.349
	400	52.682	48.860	12.269	10.870	23.814	21.182	3.010	2.586
16 days	T.W	42.63	32.630	9.347	7.048	23.133	16.770	2.744	1.881
	200	45.304	34.594	10.127	7.539	19.684	17.934	2.380	2.086
	400	48.944	40.516	11.191	8.930	21.182	19.222	2.604	2.293
24 days	T.W	38.01	29.484	8.260	6.249	16.133	14.98	1.806	1.626
	200	41.048	31.600	8.937	6.784	17.075	15.500	1.974	1.748
	400	44.058	35.430	9.800	7.727	20.207	17.390	2.380	2.006
L.S.D. at 5%		0.314	1.417	0.31	N.S	0.144	N.S	0.047	N.S
Irrigation intervals x potassium (kg K_2O/fed)									
8 days	Con.	44.016	37.814	9.777	8.245	20.328	18.018	2.492	2.088
	100	50.176	43.904	11.541	9.707	21.686	20.216	2.702	2.412
	150	52.710	47.866	12.269	10.67	23.259	21.420	2.940	2.591
16 days	Con.	40.642	31.370	8.853	6.742	19.642	16.550	2.324	1.881
	100	46.998	36.148	10.579	7.895	21.290	18.242	2.576	2.116
	150	49.238	40.222	11.233	8.88	23.0679	19.138	2.828	2.264
24 days	Con.	37.744	28.798	8.003	6.099	16.413	14.756	1.834	1.619
	100	41.538	32.440	9.170	6.982	17.598	15.920	2.030	1.784
	150	43.834	35.280	9.823	7.679	19.404	17.190	2.296	1.976
L.S.D. at 5%		0.511	1.316	0.138	0.072	N.S	0.234	N.S	0.037
Gibberellic acid x potassium(kg K_2O/fed)									
T.W	Con.	37.702	29.512	7.985	6.261	18.424	15.386	2.128	1.672
	100	43.120	34.020	9.599	7.360	19.432	16.884	2.296	1.907
	150	45.444	37.198	10.239	8.128	21.387	18.018	2.576	2.085
200	Con.	40.908	31.416	8.890	6.754	17.449	16.058	2.058	1.822
	100	45.78	36.876	10.281	8.041	19.451	17.962	2.352	2.078
	150	48.258	40.012	10.995	8.825	21.341	19.348	2.618	2.282
400	Con.	43.792	37.058	9.758	8.072	20.510	17.878	2.464	2.094
	100	49.812	41.594	11.410	9.183	21.691	19.530	2.660	2.328
	150	52.080	46.158	12.091	10.274	23.002	20.384	2.870	2.464
L.S.D. at 5%		0.511	N.S	N.S	N.S	0.160	0.234	0.041	0.037

2- Chemical composition

Data in Table (11) demonstrated that the interaction between irrigation intervals and gibberellic acid had a significant effect on crude protein and crude fiber in roots of fodder beet at the first season and on total carbohydrate at the second one and was significant also on potassium percentage during the two growing seasons. In this respect, the combination of irrigation interval at 8 days x 400 ppm gibberellic acid recorded the maximum values of crude protein, total carbohydrate, total chlorophyll and potassium percentage during 2006/2007 and 2007/2008 seasons.

The interaction between irrigation intervals and potassium fertilizer on fodder beet was significant on crude protein and potassium percentage through both seasons. The highest value of crude protein, total carbohydrate, total chlorophyll and potassium percentage obtained from 8 days irrigated with 150 kg K_2O/ fed. through the first and second seasons.

The interaction between gibberellic acid and potassium fertilizer had a significant effect on crude protein percentage during the two seasons. Gibberellic acid sprayed at 400 ppm with 150 kg K_2O/ fed. produced the highest values of crude protein, total carbohydrate, total chlorophyll and potassium percentage for both seasons.

C- Effect of the second order interactions (irrigation intervals, gibberellic acid and potassium rates)

1- Growth characters and yield:

According to results given in Table (12), the interaction among irrigation intervals, gibberellic acid and potassium fertilizer had a significant effect on top dry weight / plant at 120 and 150 day from sowing during 2006 / 2007 seasons. Treatments irrigated every 8 days, sprayed by 400 ppm gibberellic acid and fertilized by 150 kg K_2O/ fed. recorded the highest values of top dry weight, leaf area index, specific leaf weight at 120 and 150 day from sowing during both seasons.

Results presented in Table (13) showed clearly that the interaction between irrigation interval, gibberellic acid and potassium fertilizer had a significant effect on root diameter, top / roots ratio and fresh and dry weight of top at 2006/2007 and 2007/2008 seasons. Irrigation every 8 days, addition of 150 kg K_2O/ fed. and 400 ppm gibberellic recorded the highest values of root diameter and fresh and dry weight / plant of roots and top with the first and second seasons.

Table (11): Effect of the first order interactions on crude protein, total carbohydrate, crude fiber, potassium and sodium in roots as well as total chlorophyll in leaves of fodder beet plants at 180 days from sowing during winter seasons 2006/2007 and 2007/2008.

Irrigation intervals (days)		Crude protein % 2006/2007	Crude protein % 2007/2008	Total carbohydrate % 2006/2007	Total carbohydrate % 2007/2008	Crude fiber % 2006/2007	Crude fiber % 2007/2008	Total chlorophyll (mg \100g) 2006/2007	Total chlorophyll (mg \100g) 2007/2008	Potassium % 2006/2007	Potassium % 2007/2008	Sodium % 2006/2007	Sodium % 2007/2008
Irrigation intervals x gibberellic acid (ppm)													
8 days	T.W	11.01	9.81	56.69	54.19	12.05	13.30	34.95	33.05	2.95	2.57	0.90	1.09
	200	11.37	10.19	57.15	54.46	12.44	13.94	35.29	33.33	3.10	2.75	0.74	0.87
	400	11.59	10.33	57.48	55.04	12.93	14.63	35.58	33.5	3.31	2.97	0.66	0.78
16 days	T.W	10.23	9.51	56.18	53.87	12.33	14.23	34.45	32.31	2.50	2.34	1.15	1.25
	200	10.72	9.81	56.49	54.08	12.75	14.80	34.81	32.59	2.76	2.55	1.00	1.10
	400	11.02	10.04	57.05	54.39	13.09	15.27	35.23	32.8	3.03	2.73	0.84	0.98
24 days	T.W	9.52	9.24	55.74	53.11	12.69	14.99	34.06	31.94	2.28	2.11	1.33	1.46
	200	9.91	9.55	56.00	53.49	13.20	15.64	34.30	32.24	2.47	2.27	1.12	1.29
	400	10.21	9.78	56.53	54.01	13.56	16.06	34.64	32.44	2.78	2.44	0.93	1.17
L.S.D. at 5%		**0.08**	**N.S**	**N.S**	**0.06**	**0.04**	**N.S**	**N.S**	**N.S**	**0.04**	**0.04**	**N.S**	**N.S**
Irrigation intervals x potassium (kg K_2O/fed)													
8 days	Con.	11.00	9.91	56.71	54.33	12.76	14.24	34.77	33.01	2.56	2.36	0.88	1.01
	100	11.33	10.08	57.10	54.57	12.50	13.99	35.33	33.33	3.27	2.89	0.75	0.91
	150	11.65	10.34	57.51	54.79	12.16	13.64	35.72	33.54	3.53	3.04	0.68	0.82
16 days	Con.	10.31	9.56	56.12	53.73	13.07	15.11	34.43	32.22	2.36	2.25	1.08	1.25
	100	10.70	9.80	46.54	54.17	12.75	14.79	34.83	32.59	2.80	2.58	0.933	1.11
	150	10.97	10.00	57.06	54.44	12.35	14.39	35.23	32.88	3.12	2.79	0.87	0.98
24 days	Con.	9.36	9.21	55.66	53.2	13.44	15.85	33.92	31.94	2.20	2.08	1.25	1.42
	100	10.01	9.57	56.13	53.55	13.16	15.57	34.33	32.23	2.48	2.28	1.11	1.32
	150	10.27	9.78	56.46	53.86	12.85	15.26	34.75	32.46	2.86	2.46	1.02	1.18
L.S.D. at 5%		**0.05**	**0.06**	**N.S**	**0.05**	**0.05**	**N.S**	**N.S**	**0.05**	**0.04**	**0.04**	**N.S**	**0.03**
Gibberellic acid x potassium(kg K_2O/fed)													
T.W	Con.	9.90	9.24	55.71	53.38	12.67	14.49	34.08	32.13	2.20	2.03	1.27	1.39
	100	10.29	9.50	46.17	53.78	12.37	14.18	34.54	32.47	2.60	2.40	1.11	1.27
	150	10.58	9.81	56.73	54.00	12.03	13.84	34.85	32.70	2.92	2.59	1.01	1.14
200	Con.	10.25	9.61	56.13	53.70	13.09	15.09	34.36	32.43	2.34	2.24	1.05	1.20
	100	10.76	9.89	56.55	54.02	12.79	14.79	34.78	32.77	2.81	2.59	0.89	1.09
	150	10.99	10.05	56.97	54.32	12.5	14.50	35.26	32.97	3.18	2.74	0.81	0.97
400	Con.	10.52	9.82	56.64	54.18	13.50	15.62	34.68	32.61	2.58	2.42	0.90	1.08
	100	10.98	10.06	57.06	54.49	13.25	15.38	35.18	32.92	3.13	2.76	0.79	0.98
	150	11.32	10.26	57.34	54.76	12.83	14.96	35.59	33.21	3.41	2.96	0.74	0.88
L.S.D. at 5%		**0.05**	**0.06**	**N.S**	**0.05**	**0.05**	**N.S**	**0.13**	**N.S**	**0.04**	**N.S**	**0.03**	**N.S**

Table (12): Effect of the second order interactions on top dry weight, leaf area index and specific leaf weight of fodder beet plants at 120 and 150 day from sowing during winter seasons 2006/2007 and 2007/2008.

Irrigation intervals (days)	Gibberellic acid	2006/2007						2007/2008					
		120 day			150 day			120 day			150 day		
		Potassium (kg K_2O/fed)						Potassium (kg K_2O/fed)					
		Con.	100	150	Con.	100	150	Con.	100	150	Con.	100	150
		Top dry weight (g)											
8 days	T.W	38.33	43.33	48.00	67.33	70.00	76.00	30.00	36.00	42.00	49.00	58.00	65.00
	200	43.33	50.67	53.667	71.00	77.00	82.00	37.00	44.00	50.00	61.00	68.00	73.00
	400	49.67	56.33	64.33	79.00	83.00	89.00	42.00	51.00	57.00	67.00	74.00	78.00
16 days	T.W	30.33	36.33	41.33	61.00	64.00	71.00	30.00	36.00	41.00	50.00	57.00	62.00
	200	37.33	42.33	50.00	62.00	69.33	75.00	29.00	36.00	43.00	53.00	63.00	68.00
	400	43.00	52.00	59.33	69.33	78.00	83.00	35.00	45.00	51.00	59.00	66.00	73.00
24 days	T.W	24.00	29.33	35.00	48.00	54.00	59.00	19.00	24.00	30.00	42.00	47.00	51.00
	200	32.00	38.00	46.00	53.00	58.00	63.00	26.00	32.00	39.00	46.00	52.00	57.00
	400	39.33	43.00	51.00	59.00	65.00	69.00	32.00	38.00	44.00	51.00	58.00	63.00
L.S.D. at 5%		2.01			1.73			N.S			N.S		
		leaf area index											
8 days	T.W	4.21	4.50	4.64	4.70	5.07	5.19	3.90	4.19	4.30	4.12	4.70	4.86
	200	4.40	4.62	4.80	4.82	5.34	5.43	4.10	4.40	4.53	4.30	5.01	5.19
	400	4.59	4.81	4.96	4.95	5.43	5.68	4.16	4.41	4.65	4.60	5.18	5.35
16 days	T.W	4.13	4.32	4.50	4.58	4.81	4.92	3.32	3.62	3.83	4.03	4.59	4.77
	200	4.22	4.51	4.71	4.79	5.03	5.20	3.51	3.84	4.10	4.13	4.86	5.01
	400	4.43	4.57	4.80	4.81	5.14	5.39	3.73	4.11	4.26	4.39	4.90	5.19
24 days	T.W	3.70	3.90	4.07	4.06	4.32	4.52	3.21	3.43	3.63	3.75	3.99	4.13
	200	3.86	4.01	4.15	4.26	4.60	4.71	3.38	3.56	3.80	4.01	4.13	4.39
	400	3.94	4.11	4.25	4.47	4.71	4.86	3.51	3.89	4.11	4.12	4.40	4.61
L.S.D. at 5%		N.S			0.04			0.10			N.S		
		specific leaf weight (mg/cm^2)											
8 days	T.W	9.10	9.63	10.34	14.32	13.79	14.64	7.69	8.59	9.76	12.29	12.79	13.78
	200	9.84	10.96	11.18	14.73	14.41	15.09	9.03	9.99	11.00	14.32	14.25	14.75
	400	10.82	11.72	12.96	15.96	15.29	15.67	10.10	11.60	12.30	15.03	15.07	15.31
16 days	T.W	7.35	8.40	9.19	13.31	13.31	14.43	9.03	9.93	10.70	13.32	13.49	13.92
	200	8.84	9.39	10.60	12.95	13.77	14.43	8.24	9.34	10.50	13.59	14.22	14.61
	400	9.71	11.37	12.35	14.40	15.18	15.40	9.39	10.9	12.00	14.26	14.18	15.03
24 days	T.W	6.48	7.51	8.60	11.83	12.50	13.05	5.92	6.97	8.26	11.77	12.44	12.94
	200	8.28	9.67	11.07	12.37	12.62	13.37	7.70	8.98	10.30	12.23	13.25	13.67
	400	9.98	10.45	11.99	13.21	13.80	14.20	9.11	9.76	10.70	12.98	13.86	14.14
L.S.D. at 5%		0.51			N.S			0.46			N.S		

Table (13): Effect of the second order interactions on root diameter, top / roots ratio and fresh and dry weight of roots and top of fodder beet plants at 180 days from sowing during winter season of 2006/2007 and 2007/2008.

Irrigation intervals (days)	Gibberellic acid	2006/2007			2007/2008			2006/2007			2007/2008		
		Potassium ($kg\ K_2O/fed$)						Potassium ($kg\ K_2O/fed$)					
		Con.	100	150	Con.	100	150	Con.	100	150	Con.	100	150
		Root diameter (cm)						Top / roots ratio					
8 days	T.W	11.08	12.65	13.21	10.65	11.69	12.37	0.246	0.231	0.243	0.266	0.264	0.249
	200	11.74	13.42	13.94	11.09	12.29	12.78	0.243	0.237	0.243	0.272	0.251	0.251
	400	12.25	13.87	14.57	11.49	12.59	13.18	0.273	0.234	0.234	0.239	0.239	0.238
16 days	T.W	10.78	12.14	12.45	10.08	10.62	11.44	0.323	0.277	0.287	0.277	0.271	0.265
	200	11.12	12.74	13.02	10.39	11.66	12.15	0.234	0.234	0.237	0.290	0.281	0.267
	400	11.45	13.04	13.38	11.09	12.17	12.54	0.239	0.225	0.235	0.279	0.262	0.239
24 days	T.W	10.14	10.89	11.34	9.68	10.25	10.68	0.229	0.207	0.221	0.273	0.249	0.266
	200	10.34	11.44	12.05	10.02	10.85	11.54	0.215	0.213	0.233	0.261	0.252	0.268
	400	10.76	12.28	12.66	10.33	11.59	12.03	0.242	0.242	0.245	0.273	0.266	0.246
L.S.D. at 5%		0.13			0.11			0.082			0.140		
		Root fresh weight (g) / plant						Root dry weight (g) / plant					
8 days	T.W	978	1112	1169	795	918	1045	211	251	267	171	201	231
	200	1058	1174	1239	854	1034	1120	235	270	288	186	228	250
	400	1108	1298	1357	1052	1184	1254	252	303	321	232	264	281
16 days	T.W	897	1045	1103	685	789	857	189	231	247	145	171	188
	200	959	1108	1169	715	835	921	209	248	266	153	182	203
	400	1047	1204	1245	841	958	1095	234	276	289	183	211	244
24 days	T.W	818	923	974	628	723	755	170	203	217	130	154	162
	200	905	988	1039	675	765	817	191	216	231	143	164	178
	400	973	1056	1118	754	829	948	211	236	253	162	181	209
L.S.D. at 5%		20			N.S			6			N.S		
		Top fresh weight (g) / plant						Top dry weight (g) / plant					
8 days	T.W	430	474	523	397	448	479	52	58	65	45	53	57
	200	465	515	555	433	479	512	57	64	70	50	56	62
	400	557	560	584	457	517	539	69	71	75	55	63	67
16 days	T.W	526	540	586	365	407	426	61	64	71	40	46	49
	200	416	476	514	385	437	459	49	58	63	44	51	54
	400	461	505	547	432	459	482	56	62	68	51	55	58
24 days	T.W	360	374	411	337	351	382	39	42	48	35	38	43
	200	366	398	456	329	367	411	41	46	54	37	41	47
	400	447	485	512	388	419	435	51	57	62	44	48	51
L.S.D. at 5%		15			33			2			2		

Data illustrated in Table (14) recorded that the second order interaction was significant on fresh yield of roots and top through the first and second seasons. The maximum values of fresh and dry yield of roots and top were obtained by irrigated every 8 days, gibberellic acid spraying at 400 ppm with 1 5 0 kg K_2O/ fed. at both seasons.

Table (14): Effect of the second order interactions on fresh and dry yields of roots and top of fodder beet plants at 180 days from sowing during winter season 2006/2007 and 2007/2008.

Irrigation intervals (days)	Gibberellic acid	2006/2007			2007/2008			2006/2007			2007/2008		
		Potassium (kg K_2O/fed)						Potassium (kg K_2O/fed)					
		Con.	100	150	Con.	100	150	Con.	100	150	Con.	100	150
		Root fresh yield (ton/fed.)						Root dry yield (ton/fed.)					
8 days	T.W	41.08	46.70	49.10	33.39	38.56	43.89	8.86	10.56	11.23	7.20	8.45	9.70
	200	44.44	49.31	52.04	35.87	43.43	47.04	9.87	11.34	12.10	7.81	9.59	10.50
	400	46.54	54.52	56.99	44.18	49.73	52.67	10.60	12.73	13.48	9.73	11.10	11.80
16 days	T.W	37.67	43.89	46.33	28.77	33.14	35.99	7.95	9.72	10.37	6.11	7.16	7.88
	200	40.28	46.54	49.10	30.03	35.07	38.68	8.78	10.43	11.17	6.44	7.65	8.53
	400	43.97	50.57	52.29	35.32	40.24	45.99	9.83	11.59	12.15	7.68	8.87	10.20
24 days	T.W	34.36	38.77	40.91	26.38	30.37	31.71	7.14	8.53	9.11	5.48	6.47	6.81
	200	38.01	41.50	43.64	28.35	32.13	34.31	8.02	9.07	9.72	6.01	6.89	7.46
	400	40.87	44.35	46.96	31.67	34.82	39.82	8.85	9.91	10.64	6.81	7.60	8.77
L.S.D. at 5%		0.89			1.32			0.24			N.S		
		Top fresh yield (ton/fed.)						Top dry yield (ton/fed.)					
8 days	T.W	18.07	19.91	21.95	16.67	18.82	20.12	2.18	2.44	2.73	1.88	2.21	2.38
	200	19.52	21.63	23.30	18.19	20.12	21.50	2.39	2.69	2.94	2.08	2.37	2.59
	400	23.39	23.52	24.53	19.19	21.71	22.64	2.10	2.98	3.15	2.31	2.66	2.80
16 days	T.W	22.09	22.68	24.63	15.33	17.09	17.89	2.56	2.69	2.98	1.66	1.92	2.07
	200	17.47	19.99	21.59	16.17	18.35	19.28	2.06	2.44	2.65	1.85	2.13	2.28
	400	19.36	21.20	22.99	18.14	19.28	20.24	2.35	2.60	2.86	2.13	2.30	2.45
24 days	T.W	15.11	15.71	17.58	14.15	14.74	16.04	1.64	1.76	2.02	1.48	1.60	1.81
	200	15.36	16.73	19.14	13.82	15.41	17.26	1.72	1.93	2.27	1.53	1.73	1.98
	400	18.77	20.36	21.49	16.30	17.60	18.27	2.14	2.39	2.60	1.85	2.03	2.15
L.S.D. at 5%		0.28			0.41			0.07			N.S		

2- Chemical composition

Results in Table (15) revealed that the second order interaction had a significant effect on crude protein and sodium percentage in roots of fodder beet plant during the two seasons. Also, this interaction had a significant effect on crude fiber and potassium percentage through the first season, while total carbohydrate and total chlorophyll were significantly responded to that interaction at the second season. Moreover, irrigated plants every 8 days, sprayed with gibberellic acid 400 ppm and addition of 150 kg K_2O/ fed. was the best interaction treatment as compared with all treatments during the two seasons.

Table (15): Effect of the second order interactions on crude protein, total carbohydrate, crude fiber, potassium and sodium in roots as well as total chlorophyll in leaves of fodder beet plants at 180 days from sowing during winter season 2006/2007 and 2007/2008.

Irrigation intervals (days)	Gibberellic acid	2006/2007			2007/2008			2006/2007			2007/2008		
		Potassium ($kg\ K_2O$/fed)						Potassium ($kg\ K_2O$/fed)					
		Con.	100	150	Con.	100	150	Con.	100	150	Con.	100	150
		Crude protein %						Total carbohydrate %					
8 days	T.W	10.74	11.01	11.29	9.55	9.74	10.15	56.24	56.65	57.18	54.03	54.15	54.39
	200	11.05	11.38	11.67	10.05	10.19	10.33	56.74	57.20	57.52	54.22	54.47	54.69
	400	11.21	11.59	11.98	10.14	10.32	10.54	57.15	57.45	57.84	54.74	55.08	55.29
16 days	T.W	9.89	10.23	10.57	9.26	9.48	9.78	55.67	26.12	56.75	53.43	54.00	54.18
	200	10.37	10.78	11.02	9.59	9.84	10.00	56.02	56.37	57.08	53.69	54.13	54.42
	400	10.68	11.08	11.31	9.82	10.07	10.22	56.66	57.14	57.35	54.08	54.38	54.71
24 days	T.W	9.07	9.62	9.87	8.92	9.29	9.51	55.23	55.74	56.25	52.69	53.2	53.44
	200	9.34	10.12	10.27	9.20	9.63	9.81	55.63	56.07	56.3	53.18	53.45	53.85
	400	9.67	10.28	10.68	9.51	9.79	10.03	56.12	56.59	56.84	53.73	54.01	54.29
L.S.D. at 5%		0.09			0.10			N.S			0.09		
		Crude fiber %						Total chlorophyll (mg \100g)					
8 days	T.W	12.32	12.08	11.75	13.57	13.33	13.00	34.37	35.08	35.41	32.78	33.09	33.29
	200	12.74	12.42	12.15	14.24	13.92	13.65	34.81	35.28	35.78	33.07	33.38	33.55
	400	13.21	13.01	12.58	14.91	14.71	14.28	35.14	35.62	35.98	33.18	33.52	33.79
16 days	T.W	12.65	12.28	12.05	14.55	14.18	13.95	34.12	34.45	34.79	32.00	32.31	32.62
	200	13.15	12.77	12.32	15.20	14.82	14.37	34.41	34.76	35.25	32.2	32.67	32.89
	400	13.41	13.19	12.67	15.59	15.37	14.85	34.75	35.29	35.65	32.45	32.8	33.14
24 days	T.W	13.05	12.74	12.28	15.35	15.04	14.58	33.74	34.08	34.35	31.62	32.00	32.19
	200	13.39	13.18	13.03	15.83	15.62	15.47	33.87	34.29	34.75	32.01	32.25	32.47
	400	13.87	13.56	13.24	16.37	16.06	15.74	34.15	34.62	35.14	32.19	32.43	32.71
L.S.D. at 5%		0.08			N.S			N.S			0.08		
		Potassium %						Sodium %					
8 days	T.W	2.39	3.12	3.33	2.15	2.68	2.88	1.07	0.86	0.77	1.23	1.09	0.94
	200	2.51	3.27	3.52	2.35	2.89	3.02	0.85	0.73	0.65	0.95	0.87	0.80
	400	2.78	3.41	3.75	2.59	3.10	3.22	0.73	0.65	0.61	0.84	0.78	0.73
16 days	T.W	2.19	2.46	2.85	2.04	2.37	2.60	1.29	1.12	1.05	1.35	1.27	1.13
	200	2.35	2.79	3.14	2.29	2.58	2.77	1.01	0.87	0.81	1.27	1.09	0.95
	400	2.55	3.15	3.38	2.41	2.79	3.00	0.95	0.81	0.75	1.12	0.97	0.86
24 days	T.W	2.03	2.22	2.59	1.89	2.14	2.30	1.45	1.34	1.21	1.59	1.46	1.34
	200	2.16	2.37	2.88	2.09	2.29	2.43	1.29	1.08	0.98	1.39	1.31	1.16
	400	2.40	2.84	3.11	2.25	2.40	2.66	1.02	0.92	0.86	1.28	1.19	1.05
L.S.D. at 5%		0.06			N.S			0.05			0.06		

Conclusion

Under Mariut conditions, it could be concluded that, the highest growth, yield and quality of fodder beet forage was detected by irrigated every 8 days and spraying by 400 ppm gibberellic acid as well as added 150 kg K_2O/ fed.

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الاستجابة الفسيولوجية لنبات بنجر العلف للتأثير المتبادل لفترات الرى والتسميد البوتاسى والرش بحمض الجبرلين بمنطقة مريوط

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أقيمت تجربتان حقليتان على نبات بنجر العلف بمحطة بحوث مريوط بمحافظة الإسكندرية خلال موسمى 2007/2006 و 2008/2007 وذلك لدراسة تأثير ثلاثة فترات من الرى (8 و 16 و 24 يوم) وثلاثة مستويات من الرش بحمض الجبرلين (بدون – 200 و 400 جزء فى المليون) وثلاثة مستويات من التسميد البوتاسى (صفر – 120 – 150 كجم بو$_2$أ/ فدان) والتداخل بينهما على صفات النمو والمحصول العلفى والتركيب الكيماوى. حيث وزعت المعاملات فى تصميم قطع منشقة مرتين حيث وضعت فترات الرى فى القطع الرئيسية والرش بالجبرلين فى القطع الفرعية و التسميد البوتاسى في القطع تحت الفرعية موزعة فىأربعة مكررات. وكانت أهم النتائج المتحصل عليها مايلى:-

1- أدت زيادة فترات الرى من 8 إلى 24 يوم إلى نقص معنوى في صفات الوزن الجاف للعرش / نبات ودليل مساحة الأوراق والوزن النوعى للأوراق عند 120 و 150 يوم من الزراعة وقطر الجذر والوزن الغض والجاف للجذور والعرش / نبات والمحصول العلفى الغض والجاف للجذور والعرش/ فدان والبروتين الكلى والكربوهيدرات الكلية والبوتاسيوم في جذور نبات بنجر العلف ومحتوى الكلوروفيل الكلى في الأوراق عند 180 يوم من الزراعة. وعلى العكس أدت زيادة فترات الرى إلى زيادة نسبة الألياف الخام والبوتاسيوم خلال موسمى 2007/2006 و 2008/2007.

2- أدت زيادة تركيزات حمض الجبرلين من صفر إلى 400 جزء في المليون إلى زيادة الوزن الجاف للعرش / نبات ودليل مساحة الأوراق والوزن النوعى للأوراق وقطر الجذر والوزن الغض والجاف للجذور والعرش / نبات والمحصول العلفى الغض والجاف للجذور والعرش / فدان والبروتين الكلى والكربوهيدرات الكلية والبوتاسيوم في جذور نبات بنجر العلف ومحتوى الكلوروفيل الكلى في الأوراق ونقص في نسبة الألياف الخام والصوديوم.

3- أدت زيادة التسميد البوتاسى من صفر إلى 150 كجم بو$_2$أ / فدان إلى زيادة الوزن الجاف للعرش / نبات ودليل مساحة الأوراق والوزن النوعى للأوراق وقطر الجذر والوزن الغض والجاف للجذور والعرش / نبات والمحصول العلفى الغض والجاف للجذور والعرش / فدان والبروتين الكلى والكربوهيدرات الكلية والبوتاسيوم ونقص في نسبة الألياف الخام والصوديوم خلال موسمى الدراسة.

4- أدى التفاعل بين فترات الرى والرش بحمض الجبرلين والتسميد البوتاسى إلى تأثير معنوى على صفات قطر الجذر ونسبة العرش إلى الجذور والوزن الغض والجاف للعرش / نبات والمحصول العلفى الغض للجذور والعرش للفدان لنبات بنجر العلف ونسبة البروتين خلال موسمى 2007/2006 و 2008/2007.