Growth, Yield and Water Use Efficiency of Fodder Beet Responses to the NPK Fertilizer and Withholding Irrigation

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Abstract: ***Two field experiments were conducted in the experimental farm of the National Research Center, Shalakan, Kalubia Governorate, during the to successful seasons to investigate the effect of fertilization and drought on growth and yield of fodder beet plants. The treatments of Drought were: 1- Without, irrigated regularly. 2- withholding of 2nd irrigation. 3- withholding of 4th irrigation a. Fertilization treatments were: 1- Without mineral fertilization, 2- P_2O_5+K_2O, 3- N + P_2O_5, 4- N+P_2O_5+K_2O. A negative relationship was detected between withholding irrigation and growth characters of fodder beet plants. The depressive effect was significant for number of leaves, fresh weight of root and total fresh weight and dry weight of root, top and whole plant, while the differences not great enough to reach the level of significant for plant height, length and diameter of roots and fresh weight of top. The lowest fresh roots or tops yields were obtained when plants subjected to drought by withholding the 2nd irrigation followed by that when the 4thirrigation withholding compare to the plants irrigated regularly. While that lowest tops, roots and total dry yields were obtained when plants subjected to drought by with holding the 4th the irrigation followed by that when the 2ndirrigation with holding compare to the plants irrigated regularly. Furthermore, the depression in yield of roots exceeded those in tops or biological yields. Plant height, number of leaves, root diameter and length and area of leaves increased in ascending order: PK ‹ NK ‹ NPK application. Application of NP fertilizers increased the root, top and whole fresh weight/ plant and these increases were more than that obtained by KP application. Moreover, application of NPK pronouncedly increased the root, and top as well as whole plant fresh weight to reached about 2-3 fold of that of control treatment. This was fairly true for dry weight of whole plant or root and top dry weight. Positive responses of fresh as well as dry weight of tops, roots and biological yield were detected with KP, NPand NPK fertilizers. Addition of combined fertilizer NPK the superior compared to KP or NP fertilizers, meanwhile, application of NP more affective in increasing fresh or dry yields of fodder beet plants than use of KP fertilizer. Data of WUE and interaction between the both treatments were included.***

Keywords: Fodder beet-Withholding irrigation-NPK fertilizers-Growth-Yield-Water use efficiency

1. Introduction

The increasing needs, for the growing population in Egypt, for live- stock as a source for animal proteinsto cover the demands of consumption is handicapped through the shortage of the carbohydrate components inanimal feeds. Also, the horizontal expansion of new reclaimed areas requires the cultivation of crops offeringa source for satisfying income to the farmer in there areas.

Fodder beet is successfully grown as a fodder crop in many European countries and in Egypt also. The plant is used as a valuable source of fodder for cattle (Niazi,*et al.* 2000**).** Since fodder beet contains high water and sugar, it increases milk product and is suitable forage for dairy cows. The fodder beet is used by mixing with straw in European and other countries. It is also reported that the plant is suitable to make silage **(**Özen,*et al.*1993). Fodder beet has extremely high yield potential when grown on high fertile soils. Fodder beet requires large amounts of nitrogen. Nitrogen fertilizers are one of the major costs for production of these crops (Abdel-Gwad,*et al.*2008). Zamfir, *et al.* (2001) reported that increasing nitrogen fertilization increased dry matter yield and crude protein content of fodder beet.Fodder beet can easily fulfill both aims Its highcontent of carbohydrate, in the average 71.69% in dry matter and production in some new regions rangingbetween 25 -30 tons/feddan which is meaning 2000 pounds, at least as income from fodder beet followed byshort season crop such as maize adding a further cash article for the growing (Abdallah and Yassen,2008).

Drought is a major limitation to crop productivity worldwide. For most major food crops, improvement in drought tolerance is an important breeding objective, and significant advances have been made over the past 10–20 years Only recently, however, has the impact of drought been recognized as a major cause of yield losses in sugar beet (Boyer 1968;Pidgeon, *et al.* 2001, and Ober and Luterbacher, 2002).

Luković**,** *et al*. (2009) demonstrated that the highest found number of stomata per mm^2 on both adaxial and abaxial epidermis was 40% higher than the lowest. During water stress, when stomata are closed, plant survival depends on the amount of water lost through the cuticle. SEM analysis of adaxial epidermis of the lamina show that cuticle varies in texture. Considering the observed genotypic variability in cuticle ornamentation and the fact that plants develop various strategies of adaptation to drought, finding genotypes with increased drought tolerance could be based on the characteristics of the cuticle and epidermis.Mahmoodi, *et al*. (2008) noticed thatwhen the available soil water content was at 70% of field capacity, maximum root yield and quality was observed. The minimum root yield (52.5 t/ha) was observed at 90% of field capacity.

Growth characters and yield and or yield attributes of fodder beet responded positively to the fertilization with NPK fertilizers (Abd El-All1990; AbdAllah and Yassen, 2008 andSrek, *et al.* 2010).

Many trials were done by many ways to overcome the negative effect of drought on crops, an important way is the use of fertilizer on improving growth and yield under the abiotic stresses (Graciano, *et al.* 2005 and Zhu,*etal.*2009)**.**Moreover, Siam (2002) reveal that water utilization efficiency were 0.70, 0.82 and 0.85 for Sakha 102 variety at M_1, M_2 and M_3 (irrigation every 4,6 and 8 days), respectively.

Therefore, the current study was designed to investigate the effect of fertilization on ameliorate the adverse effect of drought by omitting of irrigation in some growth stages on growth and yield of fodder beet crop.

2. Materials And Methods

Two field experiments were conducted in the experimental farm of the National Research Center, Shalakan, Kalubia Governorate, during the to successful seasons to investigate the effect of fertilization and drought on growth and yield of fodder beet plants. The treatments were as follows:

Drought: 1- Without, irrigated regularly.
2- Withholding of 2nd irrigation.
3- Withholding of 4th irrigation.
Fertilization: 1- Without mineral fertilization.
2- 31 kg/fed P205+ 48 kg/fed k20.
3- 60 kg/fed N+31kg/fedP2O5.
4- 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.

The experiment included 12 treatments which were the combination between three drought treatments and 4 fertilizers treatments. The experimental design was split plot in sex replicates, two replicates for growth measurements and the rest for yield parameters. Drought treatments were in the main plots and the fertilization treatments were distributed randomizely in sub-plots.

Seeds of fodder beet(*Beta vulgaris* L.) c.v. Red forshinger were sown in 20, July in both seasons. Calcium supper phosphate (15.5% P2O5) and Potassium sulfate (48.5 % K2O) as treatments were broadcasted before soil preparation Nitrogen fertilizer as ammonium sulphate (20.5% N) in to equal portions, the first before sowing and the 2nd was applied after 2 weeks from sowing. All other cultural practices were done as in the province.

Water use efficiency (WUE) values were calculated according to the following equation:

$$\text{Water use efficiency} = \frac{\text{Yield kg/fed}}{\text{quantity of water used } m^3/\text{fed}.} \text{kg/ } m^3$$

All collected data were subjected to the proper statistical analysis using the methods described by Snedecor and Cochran (1982).

3. Results and Discussion

3.1 Irrigation withholding

3.1.1 Growth

Examination of Data in Table (1) indicated that a negative relationship was detected between withholding irrigation and growth characters of fodder beet plants. The depressive effect was significant for number of leaves, fresh weight of root and total fresh weight and dry weight of root, top and whole plant, while the differences not great enough to reach the level of significant for plant height, length and diameter of roots and fresh weight of top.

Table 1: Effect of Drought on growth of fodder beet plants (Average of two season**).**

Drought (Withholding irrigation)	Top height cm	No. of leaves	Root (cm) Diameter	Root (cm) Length	Area of leaves (cm)	Fresh weight (g): top	Fresh weight (g): Root	Fresh weight (g): Whole plant	Dry weight (g): Top	Dry weight (g): Root	Dry weight (g): Whole plant
Without(Reg.Ir)	45.5	30.9	12.83	25.38	5781	550	1442	1992	12.17	14.72	26.89
2nd irrigation	43.3	24.4	10.83	21.50	3949	240	1112	1352	9.52	8.83	18.35
4th irrigation	43.6	19.6	11.65	23.38	3842	245	1210	1455	8.53	7.77	16.30
LSDat5%	N.S	7.75	N.S	N.S	984	2.76	N.S	4.52	3.13	5.16	7.28

Abdallah and Yassen (2008) showed that extension of irrigation to 21 and 28 daysreduced the foliage fresh weight / plant although foliage dry weight and root diameter were notsignificantly affected by irrigation augmentation, but the root length /plant (cm) was seriously affectedand showed a clear reduction reaching 23.9(cm).Li, *et al.* (2004) showed thatcompared with LW treatment, MW and RW resulted in stronger seedlings, larger and deeper root system, and higher leaf area index (LAI). For RW, MW and NW, the maximum of root biomass increased 96.4, 56.6 and 21.6%, respectively, compared with that for LW.Hoffmann (2010) found that in the root, the number of cambium rings was only slightly affected, although drought stress was implemented already 6 weeks after sowing. In contrast, the distance between adjacent rings and the cell size was considerably restricted, which points to a reduced expansion of existing sink tissues. The sucrose concentration of the storage root was reduced by drought.

The depression in growth characters may be due to the effect on water and mineral absorption (Hussein, *et al.*2013) which affected the cell elongation and enlargement (Boyer, 1997 and Levitt, 1972) and this inter reflected on photosynthesis process (Ashraf and Harras, 2013), protein formation(Tarighaleslami, et al 2013), enzymes synthesis (Murthy, *et al.* 2012) and oxidative defense (Abd El-Baky, *et al*. 2014 and Sharm, *et al.* 2012).

3.1.2 Yield

Data presented in Table (2) noticed that the lowest fresh tops yields and the top, roots and total dry yields wereobtained when plants subjected to drought by withholding the 4th irrigation followed by that when the 2nd irrigation withholding compare to the plants irrigated regularly, which root yields were obtained when plants subjected to drought by withholding the 2ndirrigation followed by that when the 4th irrigation withholding compare to the plants irrigated regularly. Furthermore, the depression in yield of roots exceeded those in tops or biological yields.Drought is a major limitation to crop productivity worldwide (Boyer, 1982). For most major food crops, improvement in drought tolerance is an important breeding objective, and significant advances have been made over the past 10–20 years (Boyer, 1996). Only recently, however, has the impact of drought been recognized as a major cause of yield losses in sugar beet (Pidgeon *et al*. 2001). The adverse effect of drought on yield may be attributed to the effect of water stress on growth characters such as plant height, number and area of green leaves and fresh and dry matter of different plant parts (Kramer, 1983).

Table 2: Effect of drought on yield of fodder beet (Average of two seasons)

Drought (Withholding irrigation)	*FMY(t/fed.)*			*DMY(t/fed.)*		
	Tops	*Roots*	*Total*	*Tops*	*Roots*	*Total*
(Without irrigation)	18.010	21.071	39.081	2.709	2.842	5.551
2nd irrigation	17.019	17.263	24.282	2.567	1.591	4.158
4thirrigation	16.957	18.953	35.910	1.664	1.525	3.189
LSD at5%	N.S	N.S	N.S	0.953	0.144	1.628

FMY = Fresh matter yield.
DMY = Dry matter yield.

3.1.3WUE

Water use Efficiency WUE gave its higher value (fresh matter yield) under withholding irrigation at D1, however, when using dry matter yield, the high value of this character was by D1. Furthermore, the lowest values by fresh matter yield in regular irrigation but using dry matter yield clearly shown under withholding irrigation D2 (Table 3). This parameter did not showing any response (in fresh yield basis) to the irrigation treatments but decreased by 27.9% and 29.6% (in dry weight basis) than that treatment irrigation regularly, Siam (2002) reveal that using M_2 (watering at every 6 days) or M_3 (Watering at every 8 days) soil moisture regimes will save 17.24 and 25.17% respectively for Sakha 102 variety, but will save 17.89 and 26.3% for Giza 176 variety of the amount of water requirements.

Generally, the omitting of irrigation induced marked effect on WUE that when omitting was done with holding irrigation at D_1 or with holding irrigation at D_2, respectively.

Table 3: Water use efficiency as affected by drought. (Average of two season)

Drought (Withholding irrigation)	*Water use efficiency (WUE, kg/m3)*	
	On fresh yield basis	*On dry yield basis*
Without (Reg.Irrig).	16.29	2.33
2nd irrigation	16.32	1.68
4th irrigation	16.88	1.64

Without (Reg.Irrig) D1= Withholding 2nd irrigation D2 =Withholding 4th irrigation

Hassanli, *et al.* (2010) indicated that the highest IWUE in rootyield production (9 kg m^{-3}) was obtained using surface drip irrigation with effluent and the lowest value (3.8 kg m^{-3}) was obtained using furrow irrigation with fresh water.In drought conditions, water availability in supporting materials such as soil,vermiculite, perlite and peat-moss, is restricted, thereby causing low water use efficiency(WUE) in plant cells (Shao,*et al*. 2008). Low WUE is a primary effect on plant responses to water deficit conditions **(**Cha-Um, and Kirdmaneek*et al.* 2008). Yan Rensburg and Krüger(1993) reported that WUE declined significantly in tobacco under drought. Naito,*et al.* (1994**)** Results of this experiment led us to interpret that under water deficit resulted in higher WUE which seems to be a desirable trait under drought condition and such an affect might be due to reduction in stomatal conductance and transpiration rate that ultimately led to maintain better water status of leaves under stress conditions.

4. Fertilization

4.1 Growth

Plant height, number of leaves, root diameter and length and area of leaves increased in ascending order: PK ‹ NK ‹ NPK application. Application of NP fertilizers increased the root, top and whole fresh weight/ plant and these increases were more than that obtained by KP application (Table 4). Moreover, application of NPK pronouncedly increased the root, and top as well as whole plant fresh weight to reached about 2-3 fold of that of control treatment. This was fairly true for dry weight of whole plant or root and top dry weight.

Table 4: Effect of NPK fertilizers on growth of fodder beet plants (Average of two seasons)

Fertilizers	Top height cm	No. of leaves	Root(cm)		Area of leaves (cm)	Fresh weight (g):			Dry weight (g):		
			Diameter	Length		Top	Root	Whole Plant	Top	Root	Whole plant
Without	35.3	20.3	9.27	18.17	3720	181	717	898	10.22	10.72	20.94
KP	43.5	22.2	11.00	20.42	3869	263	833	1096	89.3	7.79	16.73
NP	483	28.0	13.37	26.33	4819	421	1381	1802	91.3	9.53	18.85
NPK	50.3	29.2	13.43	26.50	5688	514	1849	2363	11.83	13.71	25.54
LSDat5%	7.21	7.2.1.	2.42	4.06	1087	140	585	617	2.43	2.35	5.51

1) Without mineral fertilization.
2) KP: 31 kg/fed P205+ 48 kg/fed k20.
3) NP: 60 kg/fed N+31kg/fedP2O5.
4) NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.

Albayrak and Yuksel(2010)pointed out that nitrogen applications increased rootyield, dry matter yield, crude protein content, crude protein yield, root diameter and root length but decreased ADFand NDF contents of roots.

It was previously reported that root length and diameter infodder beet ranged from 7.50 to 12.99 cm and 13.51 to 24.70cm, respectively (Albayrak and Çama, 2006 andParlak and Ekiz, 2008). Present results similarto those researchers' findings.Both first and second season, nitrogenfertilization no effect dry matter content of fodder beet.However, dry matter content of fodder beet roots slightlyincreased by delayed harvest time. The highest dry determined mattercontent was last harvest time (13.25%).Although there were no statistically significant differencesamong the values of root dry matter, it was relatively lower incontrol plots than 200 kg ha-1 nitrogen fertilization. Prokopenko, *et al.* (1997) found that dry mattercontent of the fodder beet increased directly with the level offertilization. This result is consistent with the present results.

These effects may owing to the effect of these nutrients in different metabolic processes in plants. Nitrogen effects on protein building, enzymes and antioxidants. Phosphorus affect nucleic acid and ATP energy compound and potassium in cell water adjustment and carbohydrate translocation from source to sink (Marschner'sons, 2012).

4.2 Yield

Positive responses of fresh as well as dry weight of tops, roots and biological yield were detected with KP, NPand NPK fertilizers Table (5). Addition of combined fertilizer NPK the superior compared to KP or NP fertilizers, meanwhile, application of NP more affective in increasing fresh or dry yields of fodder beet plants than use of KP fertilizer. These responses may be due to the beneficial effects of these nutrients in growth characters (Marschner, 1995).

Table 5: Effect of fertilization on yield of fodder beet. (Average of two seasons)

Fertilizer	*FMY(t/fed.)*			*DMY(t/fed.)*		
	Tops	*Roots*	*Total*	*Tops*	*Roots*	*Total*
Without	11.445	13.107	24.552	1.168	1.393	2.561
KP	15.214	15.752	30.966	1.571	1.396	2.937
NP	17.056	17.729	34.785	2.180	1.373	3.553
NPK	19.200	29.795	48.995	3.478	3.781	7.259
LSD at 5%	7.94	1.793	12.17	1.278	1.428	2.591

1)Without mineral fertilization.
2)KP: 31 kg/fed P205+ 48 kg/fed k20.
3) NP: 60 kg/fed N+31kg/fedP2O5.
4)NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.

Abdallah and Yassen (2008) showed that addition of fertilizer increased growth and yield of fodder beat. Abd El-All (1990) showed that the total yield/fed reached its peak by application of 90 kg N /fed +72 k2O while maximum values root and total yield /fed were achieved by 30 kg P2O5+72 kg K2Oin both seasons. He added that the maximum values of top yield /fed were obtained by the application of 90 kg N+45 kg P2O5/fed and 90 kg/k/fed in the 2nd season ,however, application of 90 kg N+30 P2O5 kg/fed gave the highest root and total yield/fed in both seasons. Srek, *et al.* (2010) revealed that the optimal application rate of mineral fertilizers resulting in a tuber yield above 30 t ha^{-1} was 140 kg N ha^{-1}, 63 kg P ha^{-1} and 186 kg K ha^{-1}. The highest environmentally acceptable N application rate for potatoes was 120 kg N ha^{-1}, applied in the form of mineral fertilizer. Nevertheless, **Abd**El-All, *et al.* (1990) emphasized that the interaction of N,P and K fertilizers, in the all studied traits were not significant in the two seasons. This means that these nutrients affected fodder yield independently. It can be recommended the application of 90 kg N + 30 kg P2O5+ 72 kg K2O/fed for obtained higher yield of fodder yield in Monofyia governorate.The crop is a heavy K feeder but the importance of K for improving sugar beet yield. Data indicate that K fertilizers increase both leaf number and length as well as chlorophyllcontent compared to the NP control (Yu-ying and Hong*et al.* 1997).As a result of improved top growth with the application of K, there was an increase insugar beet root yield, sugar content, and sugar yield. Sharief, *et al.* (2004) found that addition nitrogen fertilizer dose (70 kg N/Fed) in the form of ammonium nitrate significantly exceeded all studied characters compared with other studied nitrogen fertilizer sources.

4.3 WUE

Results in Table (6) indicated that WUE progressively increased as the NPK fertilizer increased either in fresh or dry weight basis (Table 6).

Table 6: Water use efficiency as affected by fertilization (Average of two season)

Fertilization	*Water use efficiency (WUE, kg/m3)*	
	On fresh yield basis	*On dry yield basis*
Without	9.43	1.30
KP	15.58	1.33
NP	15.77	1.61
NPK	17.11	2.67

1- Without mineral fertilization.
2- KP: 31 kg/fed P205+ 48 kg/fed k20.
3- NP: 60 kg/fed N+31kg/fedP2O5.
4- NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.

The increases of WUE (on fresh weight basis) were 65.22, 67.23 adn81.14% and (on dry weight basis) were 2.30, 23.85 and 105.3% in comparable with the fertilized treatment. On mung bean,Zayed and Zeid (1998) reported that water stress reduces nutrientuptake by roots and transport from roots to shoots because of restricted transpirationrates and impaired active transport and membrane permeability.On wheat and maize, Fan, *et al.* (2005) mentioned thatyields and WUEs declined significantly with lapse of time except CK and MNP for wheat. Wheat yields with the N and M declined at rate of 77 and 81 kg ha^{-1} year^{-1}, but the decline of 57 kg ha^{-1} year^{-1} for NP was similar to that of 61 ha^{-1} year^{-1} for straw with N annually and P every second year (SNP). Likewise, the corn yields and WUEs declined from 160 to 250 kg ha^{-1} year^{-1} and from 0.01 to 0.03 kg m^{-3} year^{-1} among treatments, respectively.

5. Irrigation withholding X-Fertilization

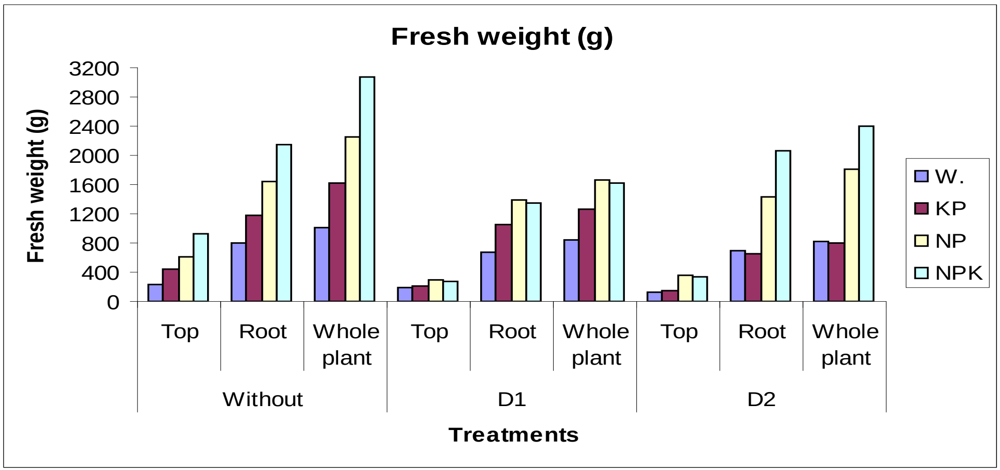
5.1 Growth

Positive effects were detected as a response to the interaction effect of combined fertilizer and drought treatments on growth characters (Table7) and Fig. (1 & 2). The interaction effect between fertilizer and irrigation water only significant on number of green leaves, area of green leaves, top fresh weight and top, root and whole plant dry weight was significant. The addition of NP gave its higher value of top height under irrigated regularly while on fresh weight of top it was under withholding 2nd and 4th irrigations, however, under all irrigation treatments for area of green leaves and top, root and whole plant dry weight.

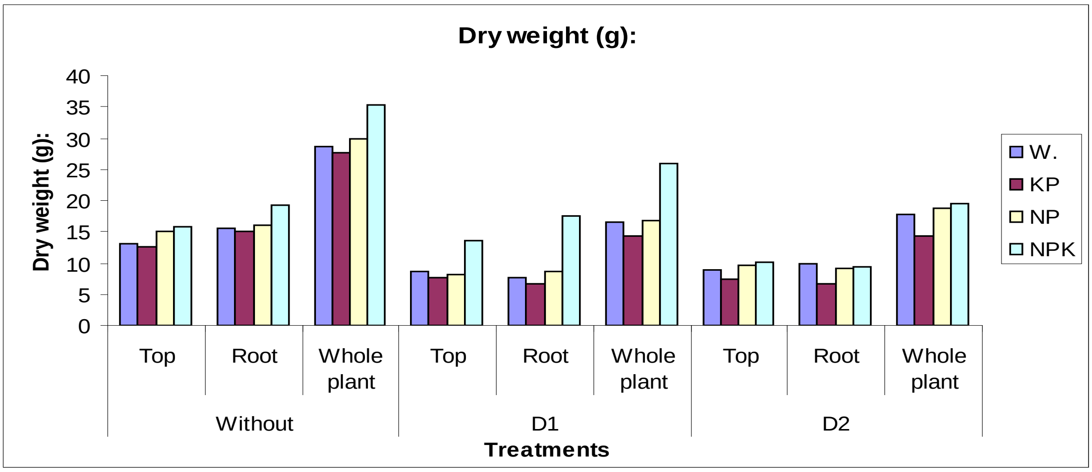
Table 7: Effect of drought and NPK fertilizers on growth of fodder beet plants (Average of two seasons)

Drough (Withholding irrigation)	Fertilizer	Top Height cm	Root(cm)		No. of leaves	Area of Leaves (cm)	Fresh weight (g):			Dry weight (g):		
			Diameter	Length			Top	Root	Whole Plant	Top	Root	Whole plant
Without	W.	35.5	9.0	19.0	24.0	4376	223	796	1019	13.13	15.48	28.61
	KP	47.2	13.0	23.0	28.5	5065	439	1181	1620	12.64	15.11	27.75
	NP	52.0	13.3	27.5	35.0	6840	615	1640	2255	15.05	15.98	31.03
	NPK	47.0	16.0	32.0	36.0	6843	921	2150	3071	15.87	19.32	35.19
2nd irrigation	W.	31.0	9.0	16.5	22.0	3089	185	665	850	8.65	7.77	16.42
	KP	42.0	10.5	18.5	23.5	3477	209	1063	1270	7.65	6.55	14.20
	NP	49.0	13.3	24.5	26.0	3578	286	1381	1667	8.23	8.57	16.80
	NPK	51.0	10.5	26.5	26.0	5650	281	1339	1620	13.56	17.41	30.97
4th irrigation	W.	39.5	9.8	19.0	15.0	3696	135	689	824	8.87	9.91	18.78
	KP	38.0	9.5	20.5	15.0	3065	141	652	793	7.51	6.72	14.23
	NP	44.0	13.5	27.0	23.0	4038	363	1441	1804	9.69	9.07	18.76
	NPK	53.0	13.8	27.0	25.5	4570	340	2057	2397	10.05	9.41	19.46
LSD at 5 %		N.S	4.78	N.S	N.S	1784	242	N.S	N.S	4.12	3.99	11.68

1) Without mineral fertilization.
2) KP: 31 kg/fed P205+ 48 kg/fed k20.
3) NP: 60 kg/fed N+31kg/fedP2O5.
4) NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.



Without (Reg.Irrig) D1= Withholding 2nd irrigation D2 =Withholding 4th irrigation
1. Without mineral fertilization. 2- KP: 31 kg/fed P205+ 48 kg/fed k20. 3- NP: 60 kg/fed N+31kg/fedP2O5. 4- NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.
Figure 1: Effect of drought and NPK fertilizers on Fresh weight (g) (Average of two seasons)



Without (Reg.Irrig) D1= Withholding 2nd irrigation D2 =Withholding 4th irrigation
1- Without mineral fertilization. 2- KP: 31 kg/fed P205+ 48 kg/fed k20.
3- NP: 60 kg/fed N+31kg/fedP2O5. 4- NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.
Figure 2: Effect of drought and NPK fertilizers on Dry weight (g) (Average of two seasons)

Snowdon and Benson (1992) noticed that total foliage mass in winter at the beginning of the experiment was 5 t ha^{-1}. After 4 years it had increased to 11 t ha^{-1} and 12.5 t ha^{-1} on control (C), F and I stands, respectively, while IF and IL stands carried 14 t ha^{-1}. Total above-ground net primary at this time was 17 (C), 20(F), 22(I), 31(IF) and 39(IL) t ha^{-1} $year^{-1}$. Annual production per unit foliage (foliar efficiency) declined with increased foliage mass but increased withfertilization and with increases in available water (rainfall and irrigation).

Zhu, *et al.* (2009) demonstrated that there was significant interaction between the water and fertilizer treatments and the negative effect of water-stress on growth and yield could be partly mitigated through the application of N andP fertilization.Mansouri-Far, *et al.* (2010) pointed out that the statistical regression analysis showed liner relationships between RGR during a period bracketing the V_8 or R_3 stages and 100-kernel weight in all the WD treatments. The increase of N supply improved yield and IWUE when maize plant endured once irrigation shortage at vegetative stage. But, the performance of high N fertilizer reduced and eliminated when water deficit imposed once at reproductive stage and twice at vegetative and reproductive stages, respectively. Furthermore, the response of T.C647 hybrid to increase of N supply was stronger than S.C647 hybrid.

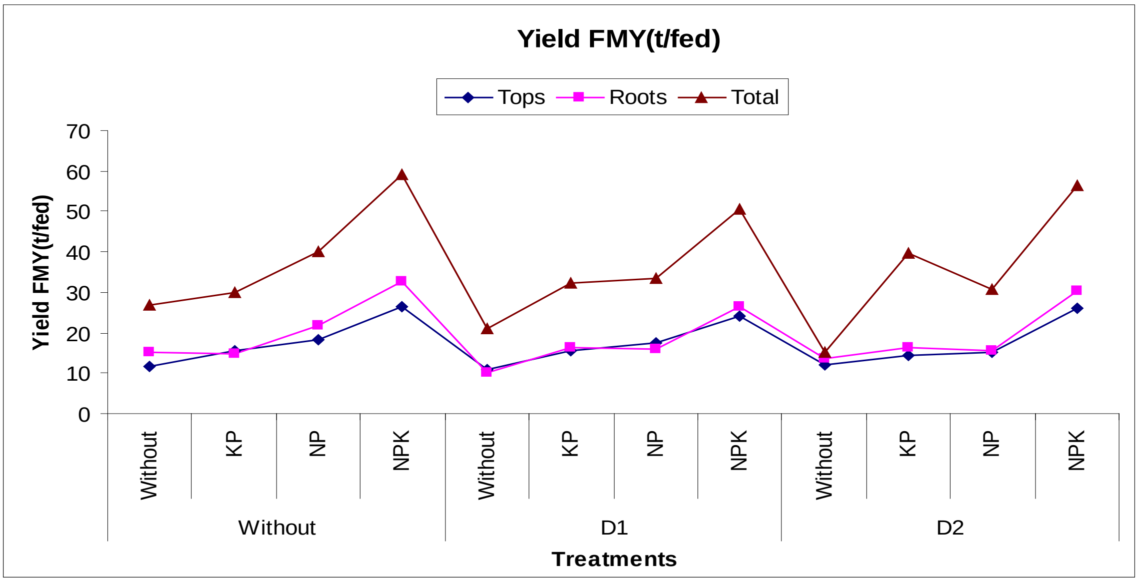
5.2 Yield

Data in Table (8) and Fig. (3 &4) cleared that withholding irrigation D1 decreased tops, roots and total yields by 5.24, 44.02 and 25.10 % respectively while this yields at withholding irrigation D_2were decreased by 38.58, 46.34 and 42.55 %, respectively when compared to that under regular irrigation. It could be concluded that the depression in yield under D2 exceeded those under D2. This may be due to the lesser effect of drought on root yield by D1 and also the high effect of drought on top yield.Application of NP fertilizers increased the root, top and whole fresh weight/ plant and increases were more than these obtained by KP application. Moreover, Application of NPK pronouncedly increased the root, and top as well as whole plant fresh weight to reached about 2-3 fold of these of control treatment. Generally the same patterns were shown (in differed degrees) under other to irrigation treatments. This was fairly true for dry weight of whole plant or root and top dry weight.

Table 8: Effect of drought and fertilization on yield of fodder beet (Average of two seasons)

Drought (Withholding Irrigation)	Fertilizer	FMY(t/fed.)			DMY(t/fed.)		
		Tops	Roots	Total	Tops	Roots	Total
Without	Without	11.578	15.240	26.718	1.506	2.150	3.656
	KP	15.521	14.588	30.109	2.545	1.796	4.341
	NP	18.400	21.866	40.266	2.819	2.204	5.123
	NPK	26.572	32.640	59.212	3.965	5.216	9.181
2nd irrigation	Without	10.708	10.292	21.000	0.925	0.800	1.725
	KP	15.588	16.508	32.096	1.068	1.416	2.484
	NP	17.660	15.920	33.580	1.862	0.880	2.742
	NPK	24.120	26.332	50.452	3.845	3.268	7.113
4th irrigation	Without	12.080	13.788	25.868	1.072	1.228	3.300
	KP	14.532	16.160	30.692	1.100	0.976	2.076
	NP	15.108	15.452	39.560	1.858	1.036	2.894
	NPK	26.108	30.412	56.520	2.624	2.860	5.484
LSD at 5%		N.S	3.105	22.98	2.130	2.473	4.627

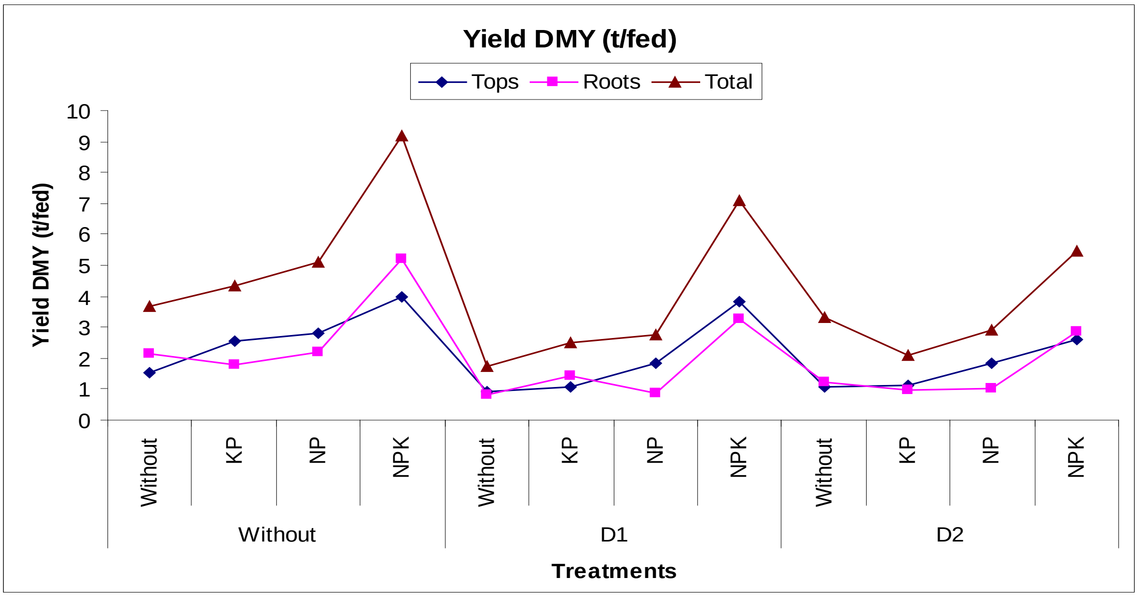
1-Without mineral fertilization.
2- KP: 31 kg/fed P205+ 48 kg/fed k20.
3- NP: 60 kg/fed N+31kg/fedP2O5.
4- NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20



Without (Reg.Irrig) D1= Withholding 2nd irrigation D2 =Withholding 4th irrigation

1- Without mineral fertilization. 2- KP: 31 kg/fed P205+ 48 kg/fed k20.3- NP: 60 kg/fed N+31kg/fedP2O5. 4- NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.

Figure 3: Effect of drought and fertilization on yield FMY (t/fed) of fodder beet(Average of two seasons)



Without (Reg.Irrig) D1= Withholding 2nd irrigation D2 =Withholding 4th irrigation

1-Without mineral fertilization. 2- KP: 31 kg/fed P205+ 48 kg/fed k20.

3- NP: 60 kg/fed N+31kg/fedP2O5. 4- NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.

Figure 4: Effect of drought and fertilization on yield DMY (t/fed) of fodder beet(Average of two seasons)

Hussein and Al-Jaloud (1995**)** concluded that application of 150–225 kg N ha^{-1} for well water irrigation and 75–150 kg N ha^{-1} for aquaculture effluent irrigation containing 40 mg N 1^{-1} would be sufficient to obtain optimum grain yield and higher WUE of wheat in Saudi Arabia. Karam, *et al.* (2009) stated that supplemental irrigation significantly increased grain number per square meter and grain weight with respect to the rainfed treatment, while nitrogen fertilization was observed to have significant effects only on grain number per square meter. Moreover, results showed that grain yield for cultivar Haurani was less affected by supplementalirrigation and more affected by nitrogen fertilization than cultivar Waha in all years. However, cultivar effects were of lower magnitude compared with those of irrigation and nitrogen. Hu, *et al.* (2009) showed plant biomass, crop yield and total P-uptake of maize were all significantly increased ($P < 0.05$) by the application of OA, 1/2 OM, andNPK, but not by the application of NK. Specifically, the individual crop yield of maize approached zero in the NK-fertilized soils, as well as in the control soils. All maize plants were colonized by indigenous AMF, and the root colonization at harvest time was not significantly influenced byfertilization.Moreover,Valadabadi, *et al.*(2009**)**noticed that, however K fertilizer significantly increased the grain growth rate of plants and althoughthe non-drought stress treatment significantly increased grain growth rate. Whereas K application persist lessdamaging of drought stress result and it enabled plant to significantly grow its grain under the droughtconditions.

WUE

The interactive effect of NPK fertilizers and withholding irrigation on WUE was presented in Table (9). Addition of NPK led to increase WUE

By 121.0, 140.2 and 276.7 % in fresh weight basis but in dry weight basis it increased by 152.0, 313.4 and 66.2 % when plants irrigated regularly, withholding the 2nd irrigation and withholding the 4th irrigation respectively.

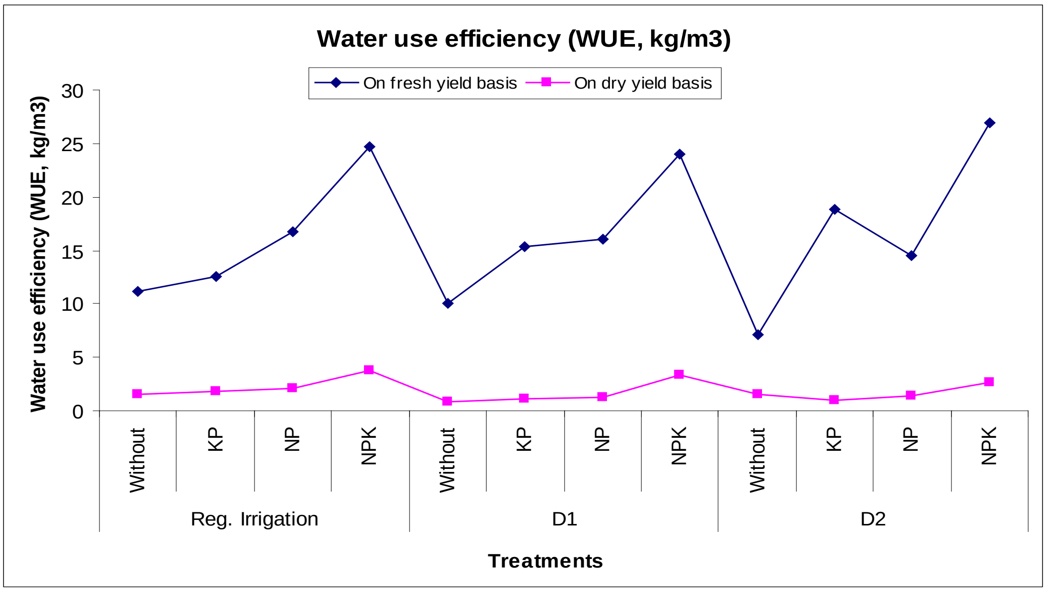
Water use efficiency increased markedly by addition of NPK fertilizers in comparable with NP, KP or without numeral fertilizers. This was true under different water regime used. Table (9) and Fig. (5). It could be mentioned that generally we can detected improving in WUE with the fertilizer treatments and the higher effects were by NPK combined fertilizer under different irrigation treatments furthermore, Siam 2002 found that.

Using Sakha 102 variety and M_2 will save 40.32% of irrigation water requirements and the grain yield will decrease with 3.23% if we cultivated one million feddan by Sakha 102 variety and watering at every 6 days will save 2800 million m^3 water every yer using for irrigation in the new soils instead using Giza 176 variety and watering every 4 days (M_1).

Table 9: Water use efficiency as affected by fertilization and drought (Average of two season)

Drought (Withholding of irrigation)	Fertilization	Water use efficiency (WUE, kg/m3)	
		On fresh yield basis	On dry yield basis
Without Reg. Irrigation	Without	11.16	1.52
	KP	12.55	1.81
	NP	16.76	2.14
	NPK	24.67	3.83
2nd irrigation	Without	10.00	0.82
	KP	15.28	1.18
	NP	15.99	1.31
	NPK	24.02	3.39
4th irrigation	Without	7.14	1.57
	KP	18.90	0.99
	NP	14.55	1.38
	NPK	26.91	2.61

W= Without mineral fertilizers
KP = P205+k20
NP = N+P2O5
NPK = N+P2O5+K2O



Without (Reg.Irrig) D1= Withholding 2nd irrigation D2 =Withholding 4th irrigation
1-Without mineral fertilization. 2- KP: 31 kg/fed P205+ 48 kg/fed k20. 3- NP: 60 kg/fed N+31kg/fedP2O5. 4- NPK: 60 kg/fed N+31kg/fed P2052+ 48kg/fed K20.
Figure 5: Water use efficiency as affected by fertilization and drought(Average of two seasons)

Li, *et al*. (2004)used four treatments which were (total water applied): rich water (RW), 400 mm; moderate water (MW), 300 mm; low water (LW), 100 mm, and natural water (NW), 212 mm. Four nutrition conditions were set up for each water treatment: high fertilizer (HF) 372 kg ha^{-1}, moderate fertilizer (MF) 248 kg ha^{-1}, low fertilizer (LF) 124 kg ha^{-1} and without fertilizer application (CK). Both soil water content and water use efficiency (WUE) increased with increasing applied water. The mean WUE were 6.37, 5.61, 5.08 and 4.40 kg ha^{-1} mm^{-1} in RW, MW, NW and LW, respectively. WUE increased by increasing applied N and P fertilizer. Compared with LW treatment, MW and RW resulted in stronger seedlings, larger and deeper root system, and higher leaf area index (LAI). For RW, MW and NW, the maximum of root biomass increased 96.4, 56.6 and 21.6%, respectively, compared with that for LW.El-Motagaly (2004) found that at the first harvest, water use efficiency (WUE) of beets was significantly increased at 50 and75% K+ substitution at 70% WHC for cultivar Evita. Under water stress conditions, WUE increased significantly at 25 and 50% K+ substitution for both cultivars (Fig. 27). At the second harvest, WUE increased significantly at 25 and 75% K+ substitution for both cultivars at 70% WHC for cultivar Evita at 40-70% WHC (Fig. 28). It is evident that at 70%

WHC, ET was found to be higher in Na+-treated plants than K+-treated plants. However, this was not observed under water stress condition.

Graciano, *et al*. (2005**)** concluded that water and nutrients are two of the most important factors controlling thegrowth of trees. Numerous studies show that fertilization is most effective when trees are not water-stressed and that irrigation is most effective when nutrients are not scarce andconclude that water stress tolerance strategies are altered by fertilization depending on soil properties, and that fertilization with P is recommended in black soils even if a moderate drought is likely to occur, but on sandy soils fertilization is recommended only under good water supply.

Hain and Zou (2009) concluded that total water consumption and water consumption rate of maize were significantly impactedby different fertilization and increased with application of chemical fertilizer and organic manure, results showed total water consumption of maize were 485.82mm, 494.83mm and 509.91mm for NF, NP and NPM, respectively, They concluded that soil water supply buffered and regulated soil water condition, and played an important role on guaranteeing crop yield; fertilizer application, can enhance soil water supply, increase crop yield and water use efficiency, especially organic manure application.,

References

[1] Albayrak, S. and Çama, N. (2006). Yield components of fodder beet (*Beta vulgaris* var. *crassa*Mansf.) under the Middle Black Sea region conditions. TarımBilim. Derg., 12 (1): 65-69.

[2] Albayrak, S. and Yuksel, O. (2010). Effect of nitrogen fertilization and harvest time on root yield and quality of fodder beet *(Beta vulgaris var. creassaMansf.)*.Turkish Journal of Field Crops, 2010, 15(1): 59-64.

[3] Abd El-Aal, S.M. (1990). Effect of nitrogen, phosphorus and potassium fertilization on theproductivity of fodder beet (*Beta vulgaris*, L.). Egypt. J. of Agron., 15(1-2): 159-170.

[4] Abd El-Aal, S.M. and M.E. Ibrahim (1990). Effect of nitrogen and some micro-nutrients fertilizationon the growth, productivity and quality of sugar beet (*Beta vulgaris*, L.) J. Agric. Res.Tanta Univ., 16(4): 703-714.

[5] Abdallah, E.F. and Yassen, A.A. (2008). Fodder Beet Productivity under Fertilization Treatments and Water Augmentation. Australian Journal of Basic and Applied Sciences, 2(2): 282-287.

[6] Abdel-Gwad, M.S.A.; El-Aziz, T.K.A. and El-Galil, M.A.A. (2008). Effect of intercropping wheat with fodder beet under different levels of N-application on yield and quality. Annals of Agric. Sci. (Cairo) 53 (2): 353-362.

[7] Abd El Baky, H.H.; Hussein, M.M. and El-Baroty, G.S. (**2014**). (AJABS).

[8] Induces of antioxidant compounds and salt tolerance in wheat plants irrigated with sea water as application of microalgae spray. American Journal of Agricultural and Biological Sciences, 9 (2): 127-137.

[9] Ashraf, M. and P.J.C. Harras, P.J.C. (2013). Photosynthesis under stressful environments: An overview. Review. Photosynthetica, 51 (2): 163-190.

[10] Boyer,J.S**.** **(**1982). Plant productivity and environment. Science, 218*:* 443–448.

[11] Boyer, J.(1968). Relationship of water potential the growth of leaves. Plant physiology 43: 1056-62.

[12] Boyer, J.S**.(**1996). Advances in drought tolerance in plants. Advances in Agronomy 56*:* 187*–218*.

[13] Cha-Um, S. and Kirdmaneek, C.(2008). Effect of osmotic stress on praline accumulation, photosynthetic abilities and growth of sugarcane plantilets (*Saccharumofficinarum L*.). Pak. J. Bot., 40(6): 2541-2552, 2008.

[14] El-Motagaly, F.M. (2004). Evaluation of two sugar beet cultivars (*Beta vulgaris* L.)for growth and yield under drought and heat conditions.Institute of Plant Nutrition, JustusLiebigUniversityGiessen, Germany.

[15] Hanan (2002). Chemistry of submerged soils and relation together and yield of rice. pH.D Thesis, Fac. of Agric. Cairo University., Giza.

[16] Fan, T.; Stewart, B.A.; Yong, W.; Junjie, L. and Guangye, Z. (2005). Long-term fertilization effects on grain yield, water-use efficiency and soil fertility in the dryland of Loess Plateau in China Original Research Article. Agriculture, Ecosystems & Environment, 106 Issue 4: 313-329.

[17] Graciano, C.; Guiamét, J.J. and Goya, J.F. (2005). Impact of nitrogen and phosphorus fertilization on drought responses in *Eucalyptus grandis* seedlings Original Research Article. Forest Ecology and Management, 212, Issues 1-3: 40-49.

[18] Hassanli, A.M.; Ahmadirad, S. and Beecham, S. (2010). Evaluation of the influence of irrigation methods and water quality on sugarbeet yield and water use efficiency Original Research Article. Agricultural Water, 97 (2), 357-362.

[19] Hain, X. and Zou, W. (2009). Influence of Different Fertilization on moisturecharacteristics of Black Soil under Drought Year in Semi-arid Regions inNortheast China Geophysical Research Abstracts, 11: 3322.

[20] Hoffmann, C.M. (2010).Sucrose accumulation in sugar beet under drought stress. Journal of Agronomy and Crop Science 196, Issue 4: 243–252.

[21] Hu, J.; Lin, X.L.; Wang, J.; Dai, J.; Cui, X.; Chen, R. and Zhang, J. (2009). Arbuscularmycorrhizal fungus enhances crop yield and P-uptake of maize *(Zea mays L.*): A field case study on a sandy loam soil as affected by long-term P-deficiency fertilization Original Research Article. Soil Biology and Biochemistry, 41, Issue 12: 2460-2465.

[22] Hussein, G. and Al-Jaloud, A.A.(1995).Effect of irrigation and nitrogen on water use efficiency of wheat in Saudi Arabia. Agric. Water Manag., 27 Issue 2:143-153.

[23] Hussein, M.M**;**Safaa, A. Mahmoud and Taalab, A. S.(2013). Yield and nutrient status of barley plant in response to foliar application of fertilizers under water deficit conditions.Journal of Applied Sciences Research, 9(7): 4388-4396.

[24] Karam, F.; Kabalan, R.; Breidi, J.; Rouphael, Y. and Oweis., T. (2009). Yield and water-production functions of two durum wheat cultivars grown under

differentirrigation and nitrogen regimes Original Research Article. Agricultural Water Management, 96 Issue 4: 603-615.

[25] Kramer, P. J. (1983). Water Relations of Plants.Elsever Science Publisher.

[26] Levitt, J. (1972).Responses of plants to environmental stresses**.** Acad. Press.

[27] Li, W.; Li, W. and Li, Z. (2004).Irrigation and fertilizer effects on water use and yield of spring wheat in semi-arid regions. Agric. Water Manag., 67 Issue 1: 35-46.

[29] Luković,J.; Maksimović, I.; Zorić, L.; Nagl, N. Perčić̓ , M.; Polić, D. and Putnik-Delić, M. (2009**).** Histological characteristics of sugar beet leaves potentially linked to drought tolerance. Industrial Crops and Products 30, Issue 2: 281-286.

[30] Mahmoodi, R, Maralian, H. and Aghabarati, A. (2008). Effects of limited irrigation on root yield and qualityof sugar beet (*Beta vulgaris* L.).African Journal of Biotechnology 7 (24): 4475-4478.

[31] Mansouri-Far, C.; Sanavy, S.A. and Saberali, S.F. (2010). Maize yield response to deficit irrigation during low-sensitive growth stages and nitrogen rate under semi-arid climatic conditions Original Research Article. Agricultural Water Management, 97 Issue 1: 12-22.

[32] Marschner, H. (1995). Minerals Nutrition in Higher plants. Acad. Press, New York.

[33] **Marschner, P. H. (2012).Marschner's Mineral Nutrition of Higher plantsKluwer Academic Publisher**s.**www.books.google.com.eg/books?isbn=0123849055.**

[34] Murthy, S.M.; Devaraj, V.R.; Anitha, P. and Tejavathi, D.H.(2012).

[35] Studies on the activities of antioxidant enzymes under induced drought stress in vivo and in vitro plants of *Macrotylomauniflorum (Lam.) Verdc.*Recent Research in Science and Technology, 4(2): 34-37.

[36] Naito, H.; Tsuchiya, M. and Kumano, S. (1994).Physiological response to salinity in rice plant. II. Effect of transpiration and root respiration on sodium uptake in NaCltreated rice plant. Jap. J. Crop Sci. **63**, 320-325.

[37] Niazi, B. H.; Rozema, J.; Broekman, R.A. and Salim, M. (2000). Dynamics of growth and water relations of fodder beet and sea beet in response to salinity. Journal of Agron. and Crop Sci. 184: 101-109.

[38] Ober, E.S. and Luterbacher, M.C. (2002). Genotypic Variation for Drought Tolerance in *Beta vulgaris*Annals of Botany,89, Issue7917-924.

[39] Özen, N.; Çakır, A.; Ha, S.andveAksoy, S. (1993). YemlerBilgisi veYemTeknolojisiDersNotları: 50. Atatürk UniviversitesiErzurum Parlak, A.O. VE Ekiz, H. (2008). Ankarako_ullarındabazıyemlikpancar (*Beta vulgaris* L. ssp. *crassa*Mansf.) çe_itlerininverimveverim ö_eleribakımındankar_ıla_tırılması. TarımBilim. Derg., 14 (2): 95-100.

[40] Pidgeon, J.D.; Werker, A.R.; Jaggard, K.W.; Richter, G.M.; Lister, D.H. andJones, P.D.(2001). Climatic impact on the productivity of sugar beet (*Beta vulgaris L.)* in Europe1961–1995. Agricultural and Forest Meteorology,109*:* 27–*37.*

[41] Prokopenko, L.S.; Olonicheva, R.V. and Pidpalii, I.F. (1997). Amino acid composition and protein nutritive value of fodder beet. VisnikAgrarnoiNauki, 1: 26-28.

[42] Sharief, A.E.; Attia, A.N. ; Salama, A.A. and Mousa, A.E. (2004).Effect of nitrogen fertilizer sources and time of splitting on root yield and quality of sugar beet in North Delta. The 4th Scientific Conference of Agricultural Sciences, Assiut, December, 2004.

[43] Sharma, P.; Jha, A.B.; Dubey, R.S. and Pessarakli, M. (2012). “Reactive Oxygen Species, Oxidative Damage, and Antioxidative Defense Mechanism in Plants under Stressful Conditions,” Journal of Botany, vol. 2012:1-26.

[44] Shao, H.B.; Chu, L.Y.; C.A.Jaleel and Zhao, C.X.(2008). Water-deficit stress-induced anatomicalchanges in higher plants. Comp. Ren. Biol., 331: 215-225.

[45] Snedecor,G. W. and. Cochran, W. C (1982**);** Statistical Methods,Oxford andIBH publishing G. 7th ed.Iowa State univ. Press.Iowa USA.

[46] Snowdon, P. and Benson, M.L. (1992). Effects of combinations of irrigation and fertilization on the growth and above-ground biomass production of *Pinusradiata* Original Research Article. Forest Ecology and Management, 52, Issues 1-4: 87-116.

[47] Šrek, P.; Hejcman, M. and Kunzová, E. (2010). Multivariate analysis of relationship between potato (*Solanumtuberosum*

[48] L.)yield, amount of applied elements, their concentrations in tubers and uptake in a long-term fertilizer experiment Original Research Article. Field Crops Research, 118, Issue 2: 183-193.

[49] Tarighaleslami, M.; Zarghami, R.; Mashhadi, A M.; Boojar, K. and MeysamOveysi, M. (2013).Effects of Drought Stress and Different Nitrogen Levels on Morphological Traits of Proline in Leaf and Protein of Corn Seed (*Zea mays* L.). American-Eurasian J. Agric. & Environ. Sci., 12 (1): 49-56

[50] Valadabadi, S.A.; Farahani, H.A. and Khalvati, M.A.(2009). Evaluation of grain growth of corn and sorghum under K2O applicationand irrigation according. Asian Journal of Agricultural Sciences, 1(1): 19-24.

[51] Yan Rensburg, L. V. and G. Krüger, H.J. (1993).Comparative analysis of differential drought stress-induced suppression of and recovery in carbon dioxide fixation: stomatal and non- stomatal limitation in *Nictianatobaccum*. J. Plant Physiol.142, 296-306.

[52] Yu-ying, L. and Hong, L.(1997). Effects of Potassium Fertilizers onSugar Beet Yield and Quality.Better Crops International, 11(2): 24-25.

[53] Zayed, M. A. and Zeid, I.M. (1998**).** Effect of water and salt stresses on growth, chlorophyll, mineral ions and organic solutes contents, and enzymes activity in mung bean seedlings. Biol. Plant. 40(3), 351-356.

[54] Zamfir, I.; Zamfir, M.C.; Dihoru, A. and Dumitru, E. (2001). The long-term fertilization influence on both fodder beet yield and some featuresof argilluvialchernozem from Burnas plain. AnaleleInstitutului de Cercetari pentruCerealesiPlanteTehnice, Fundulea, 68 : 289-299.

[55] Zhu, Z.; Liang, Z.; Han, R. and Wang, X. (2009). Impact of fertilization on drought response in the medicinal herb *Bupleurumchinense* DC.: Growth and saikosaponin production. Industrial Crops and Products, 29 Issues 2-3: 629-633).