Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 06 | Issue : 04 | Oct.-Dec. | 2017
Pages:1295-1300

Influences of Irrigation and Fertilizer on Growth and Yield of Two Sugar Beet Varieties in Egypt

Mehanna H.M., Safi-naz S. Zaki and Hussien M. M.

Water Relations and Irrigation Dept., Agri. & Bio. Division, National Research Centre, Cairo, Egypt

Received: 24 Oct. 2017 / Accepted: 10 Dec. 2017 / Publication date: 22 Dec. 2017

ABSTRACT

Two field experiments were conducted in the Experimental farm of the National Research centre, El-Nobaria, El-Boheira Governorate, Egypt, during two seasons (2013-2014 & 2014-2015) to evaluate the growth of root and yield of sugar beet (*Beta vulgaris* L.). The experimental treatments were as following: (a) two sugar beet varieties (Samba and Farida), (b) three irrigation water regimes (2483, 1862 and 1241 m^3/fed./season) under drip irrigation system, and (c) four NPK fertilization rates (0, 0, 0) as control, (50, 75, 25), (75, 110, 35) and (100, 150, 50) as quantity of compound NPK fertilizers, respectively. The results were: Samba variety was the superior in root characters i.e. length, and diameter, and yield of roots and sugar/fed., water stress induced by irrigated sugar beet plants with the lowest water regime which depressed the root parameters as well as yield of roots and sugar/fed. Root diameter and yield of roots and sugar showed its higher values under the moderate water regime (1862 m^3/fed.). For water productivity of root yield, it was observed that the highest values were gained using the lowest quantity of water. Generally, it was obviously that Samba variety which irrigated by the moderate water regime (1862 m^3/fed./season), and fertilized by the highest amount of NPK (100, 150, 50) produced the economic root and sugar yield of sugar beet and saved 621 m^3/fed./season, which is the main concern now a days for the arid regions.

Key words: Sugar beet *(Beta vulgaris* L.), Irrigation water regime, Varieties, Fertilization, Root growth, Root yield, Sugar yield.

Introduction

Sugar beet (*Beta vulgaris* L.) is one of the most important crops and comes the second one after sugar cane as sugar production in Egypt (Abd El-Motagally and Attia, 2002). Sugar production plays an important and enormous role in Egyptian economy.

Using suitable irrigation strategies with sugar beet can mean a healthy crop with higher yield and quality potential. Applied irrigation just before the available soil water is depleted to 60% and replenishing available soil water near field capacity in appropriate root zone will greatly assist in producing high quality and high yielding of sugar beet crop (Efetha, 2012). Drought is one of the major factors causing harmful losses for sugar beet crop.

Many investigators have confirmed the role of N and K for increasing the yield and quality of sugar beet by enhancing the biosynthesis of organic metabolites and improving the nutritional status (Oshea *et al.,* 2009). Marinkovik *et al.* (2008) increased phosphorus fertilizer (P_2O_5) from 50 to 150 Kg/ha increased growth and yield of sugar beet. Seadh (2012) found that the highest yield of sugar beet was produced using 80 Kg/fed. N, 30 Kg/fed. P_2O_5, and 48 Kg/fed. K_2O).
Barlog *et al.* (2013) used different NPK rates to fertilize sugar beet plants in field experiments and reported that the highest yield was obtained with the highest amount of N, P, K and Ca in the favorable weather condition. Kandil (2016) noticed that that potassium fertilization induced increases in the sugar beet parameters, where the three sugar beet varieties under study showed significant differences in several characters except sucrose percentage. Masri *et al*. (2015) studied the influence of using 50% irrigation water requirement and five fertilization treatments. They found that drip irrigated sugar beet plants with 75% of irrigation water requirements recorded the highest significant leaf area index, sucrose%, in both seasons and white sugar yield in the second season only.

Therefore, the objective of this work is to study the effect of ferti-gation by combined

Corresponding Author: Mehanna, H.M., Water Relations and Irrigation Dept., Agri. & Bio. Division, National Research Centre, Cairo, Egypt. E-mail: hany_mehana222@yahoo.com

fertilizers under different water regimes on growth, water productivity and yield of two sugar beet varieties.

Materials and Methods

Two field experiments were conducted in the Experimental farm of the National Research Centre, El-Nobaria, El-Boheira Governorate, Egypt, during two seasons (2013-2014 & 2014-2015) to evaluate the sugar beet growth of root and yield of root and sugar. The physical and chemical properties of the soil are presented in Table (1).

Table (1 a &b): (a) Some physical properties of the experimental site soil.

Texture soil	Particles size distribution (%)		
	Clay	Silt	Sand
Sandy loamy	20	10	70

(b)Some chemical properties of the experimental site soil.

pH (2.5:1)	EC (1:5) dSm^{-1}	Cations meq/L				Anions meq/L			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
8.1	0.58	1.0	0.5	3.6	0.9	-	1.9	3.5	0.6

The treatments were as the following: two sugar beet varieties (Samba and Farida), three irrigation water regimes (2483, 1862 and 1241 m^3/fed./season, the irrigation quantities were calculated from the meteorological data in the region as a percentage of the Etc of sugar beet crop, under drip irrigation system, and four NPK fertilization rates [F1 (0 ,0 ,0) as control, F2 (50, 75, 25), F3 (75, 110, 35) and F4 (100, 150, 50) as quantity of NPK compound fertilizers, respectively].

The experiment included 24 treatments as a combination of two varieties, three water regimes and four fertilization treatments. The design of the experiment was split, split plot in six replications. The fertilization treatments were distributed randomize in the water regime treatments in both studied varieties treatments.

Seeds of sugar beet varieties (*Beta vulgaris* L.) were sown at 15th Nov. for two successful winter seasons. The fertilizer treatments were broadcasted in two equal portions, the 1st before sowing and the second three weeks later. Irrigation treatments were applied at 21 days after sowing. All other agricultural practices were done as recommended in the Province. All collected Data were subjected to the proper statistical analysis methods described by Snedecor and Cochran (1990).

Water productivity was calculated by dividing the yield on the quantity of irrigation water (Kg/m^3).

Results and Discussion

Varietal differences

Data in Table (2) indicated that Samba variety was the superior in root diameter, and yield of roots and sugar per fadden, but there was no significance in root length and sugar yield for the two studied varieties. Hussein et al. (2008) found that FD99 variety surpassed Cordova variety on plant height, number of leaves, root length and root diameter but did not find any significant differences in fresh weight between the two sugar varieties, (FD99 and Cordova). Shaaban et al. (2010) and Stevens *et al*. (2008) demonstrated varietal differences between three sugar beet *varieties*. El-Sheikh *et al*. (2009) reported the significant varietal variation within all tested genotypes under study in root fresh weight, yield/fed., but the differences in length and diameter of roots and sugar % were not significant. While Enan *et al*. (2009) pointed out that sugar beet varieties differ in root yield and length and diameter of roots. However, Shalaby *et al.* (2011) tested three genotypes (Gazella, Carola and Lola) showed the differences between them in growth, yield and mineral contents under Egyptian conditions.

Water regime

It is clear from data in Table (2) that water stress induced by irrigated sugar beet plants with the lowest water regime (1241 m^3/fed.) depressed the root parameters as well as yield of roots and sugar. Root (length & diameter), yield of roots and sugar showed their higher values under the moderate water regime (1862 m^3/fed.), but water productivity for root yield (Kg/m^3) increased as the water quantity decreased up to the lowest level used. On the other hand, the highest value of water productivity of sugar yield (kg/m^3) was by using the moderate water regime (1862 m^3/fed.). Abo Shady *et al*. (2010) revealed that increasing the drought period resulted in a significant increase in root length, root/top ratio, gross sugar % and white sugar % and decreased root and top yield, root diameter, while white and gross sugar yield, soluble non-sugar content as well as sugar purity were not affected. Water deficit showed relatively the smallest leaf growth.

Hussein and Sieam (2012) demonstrated that fodder beet plants fresh and dry weight affect significantly by withholding irrigation (2nd and 4th irrigations). In addition, Topak *et al.* (2011) showed that increasing water deficits resulted in a lower root and white sugar yield.

Table 2: The influence of the individual experimental treatments on growth, root and sugar yields of two sugar beet varieties (means of two seasons).

Sugar beet Varieties	Length of root, cm	Diameter of root, cm	Root yield, Mg/fed.	Sugar yield, Mg/fed.	Water productivity for root yield, Kg/m^3	Water productivity for sugar yield, Kg/m^3
Samba	33.78	31.20	29.23	4.57	16.56	2.58
Farida	34.12	30.19	28.70	4.27	16.47	2.41
L.S.D. at 5% level	N.S.	0.06	0.08	N.S.	0.09	N.S.
Water regime (m^3/fed.)	Length of root, cm	Diameter of root, cm	Root yield, Mg/fed	Sugar yield, Mg/fed	Water productivity for root yield, Kg/m^3	Water productivity for sugar yield, Kg/m^3
2483	35.40	33.33	30.77	4.17	12.39	1.68
1862	35.62	34.68	31.37	5.67	16.84	3.05
1241	30.82	24.09	24.76	3.42	19.95	2.76
L.S.D. at 5% level	0.73	0.07	0.11	0.39	0.10	0.21
Fertilizer NPK treatments	Length of root, cm	Diameter of root, cm	Root yield, Mg/fed	Sugar yield, Mg/fed	Water productivity for root yield, Kg/m^3	Water productivity for sugar yield, Kg/m^3
0 , 0 , 0	32.54	28.12	27.00	3.82	15.19	2.16
50,75,25	32.95	29.39	28.97	4.46	16.45	2.51
75,110, 35	34.70	31.63	29.47	4.47	16.72	2.55
100,150,50	35.59	33.65	30.42	4.93	17.22	2.76
L.S.D. at 5% level	0.71	0.11	0.09	0.37	0.05	0.19

Fertilization

There is a positive relationship between fertilizers quantity and growth as well as yield of roots and sugar. The maximum values of root parameters and yield of sugar and roots were achieved by the highest rates of fertilizers used (Table, 2). Water productivities for root and sugar yields were increased by the increment of NPK rate to the highest level (NPK, 100, 150, 50, respectively). Marinkovik *et al.* (2008) showed that by increasing amounts of phosphorus from 50 to 100 and 150 Kg P_2O_5/ha, root and sugar yields were increased. Seadh (2012) reported that maximum values of sugar beet growth and yield could be achieved by fertilizer of 100% of the recommended dose of NPK. For achieved a high yield of root and sugar it is very important to adding balanced NPK fertilizer. In the experiment they found that this rate of fertilizer was N (150) P(150) K(120) Kg/ha (Barlog *et al.*, 2013). Therefore, any efforts towards fulfillment this objective requires to take into account both N and other nutrients, especially of P and K (Grzebisz *et al.,* 2012).

Varieties x water regime x fertilization

The interaction effect of sugar beet varieties, water regimes and fertilization rate on root characters and sugar yields were presented in Table (3). These Data showed that fertilizer application improved growth and yields of the two sugar beet varieties. The highest root yield was obtained in Samba variety by fertilized plant with the highest rate of NPK and irrigated by the moderate water quantity (1862m^2/fed.) followed by that in Farida with the same quantities of water and fertilizer. On the opposite side, the lowest root yield was shown when plants grown without fertilizers and using the lowest water quantity.

Table 3: The influence of the interaction of the experimental treatments on growth, root and sugar yields of two sugar beet varieties (means of two seasons).

Sugar beet Varieties	Water regime, m^3/fed.	Fertilizers NPK treatments	Length of root, cm	Diameter of root, cm	Root yield, Mg/fed	Sugar yield, Mg/fed	Water productivity for root yield, kg/m^3	Water productivity for sugar yield, kg/m^3
Samba	2483	0 , 0 , 0	35.20	30.90	29.42	4.00	11.85	1.61
		50,75,25	33.80	32.55	30.99	4.12	12.48	1.66
		75,110, 35	35.90	34.80	31.00	4.50	12.49	1.81
		100,150,50	37.70	36.90	32.60	5.05	13.13	2.03
	1862	0 , 0 , 0	33.15	31.70	29.77	4.84	15.99	2.59
		50,75,25	35.10	33.25	31.04	5.91	16.67	3.17
		75,110, 35	36.60	37.30	32.05	6.04	17.21	3.24
		100,150,50	38.50	38.20	33.72	6.07	18.11	3.26
	1241	0 , 0 , 0	30.05	22.80	22.43	3.19	18.08	2.57
		50,75,25	30.55	23.15	25.72	3.31	20.73	2.67
		75,110, 35	30.89	24.70	25.93	3.88	20.89	3.12
		100,150,50	31.27	28.20	26.12	3.93	21.04	3.16
Farida	2483	0 , 0 , 0	34.80	30.22	29.04	3.61	11.69	1.45
		50,75,25	33.40	31.86	30.44	3.83	12.26	1.54
		75,110, 35	35.30	33.56	30.94	3.34	12.46	1.34
		100,150,50	37.10	35.81	31.73	4.89	12.78	1.97
	1862	0 , 0 , 0	32.80	31.00	29.21	4.21	15.69	2.26
		50,75,25	34.70	32.87	30.71	6.47	16.49	3.47
		75,110, 35	36.00	35.78	31.84	5.79	17.10	3.11
		100,150,50	38.10	37.33	32.55	6.05	17.48	3.25
	1241	0 , 0 , 0	29.25	22.10	22.15	3.05	17.85	2.46
		50,75,25	30.15	22.63	24.94	3.15	20.09	2.54
		75,110, 35	33.52	23.64	25.05	3.28	20.19	2.64
		100,150,50	30.88	25.46	25.77	3.58	20.79	2.88
L.S.D. at 5% level			1.74	0.27	0.22	0.89	0.12	0.48

Masri *et al.* (2015) reported that drip irrigated sugar beet plants with 75% of irrigation water requirements (IWR) recorded the highest significant leaf area index, sucrose%, purity% and extractable sugar% in both seasons and white sugar yield in the second season only, while application of sprinkler irrigate at 100% of IWR gave the heaviest root weight, root number, purity%, root yield in both seasons. Applying compost (5 ton/fed) with sprinkler irrigation significantly increased root weight, root number and root yield in the both seasons. Also, application of compost (5 ton/fed) with drip irrigation system increased root yield. Increasing N rate up to 120 Kg N/fed significantly increased LAI, individual root weight, root number/fed and impurities percentage as well as root yield (ton/fed) in both seasons and white sugar yield (ton/fed) only in the first season. Excessive N application lowered beet quality in terms of sucrose, purity and extractable sugar percentage in both seasons. Jafornia *et al*. (2013) observed that by increasing nitrogen application up to 200kg/ha, the percentage of extractable sugar and pure sugar in root pulp were increased.

Neseim *et al.* (2014) showed that the recommended K dose (75 Kg/fed) in combination with yeast (14 g/L) recorded the highest yield, sucrose %, water use efficiency and the lowest impurities % under drought stress. Also, the application of 100 Kg/fed potassium fertilization in combination with 10g/L yeast recorded the highest root yield and white sugar yield, water use efficiency as well as, under sufficient irrigation. Suna *et al.* (2015) indicated that there was a clear tendency that PRD irrigation could enhance the allocation of DM and P into the root, increase root to shoot ratio and insignificantly increase PUE. Therefore, the use of PRD irrigation may potentially improve both WUE and PUE for potato production in areas with limited freshwater resources. Ragab and Rashed (2011) revealed that significant interaction effects were found between main three factors under study illustrated that spacing hill 20cm between plants, prevention irrigation before harvest by 30 days with used Farida cultivar gave the highest values for most important characters under study.

The sugar yield had the same trend, but the highest yield (not significant) was achieved by NPK (50, 75, 25), and irrigated by the same quantity of water for Farida variety. On reverse, the lowest sugar yield resulted in treatment without fertilizer application and irrigated with the lowest quantity of water in both varieties. Abo Shady *et al.* (2010) reported the significant response of the interaction of irrigation x varieties x potassium fertilization in root length or diameter and top to root ratio of sugar beet.

For water productivity of root yield, it was observed that the highest values were gained using the lowest quantity of water. On the contrary, for water productivity of sugar yield, the moderate quantity of irrigation water (1862 m^3/fed.) produced the highest values of sugar for the water unit. Generally, the water productivity, it was shown continuous increases were detected as the decreases in the irrigation water quantity. The reverse was true for the increases in the rates of combined fertilizers. On fodder beet, Hussein and Sieam (2012) demonstrated that 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.

Conclusion

It was obviously that Samba variety which irrigated by the moderate water regime (1862 m^3/fed./season), and fertilized by the highest amount of NPK (100, 150, 50) produced the economic root and sugar yields of sugar beet and saved 621 m^3/fed/season, which is the main concern nowadays for the arid regions.

References

Abd El-Motagally, F. and K.Attia, 2002. Response of sugar beet plants to nitrogen and potassium in sandy calcareous soil. Intr. J. of Agric. & Biol. 11(6): 695-700.

Abo Shady, Kh. A., S.M. Hillal, El-Shrief, E. El. and M. Ibrahim, 2010. Yield and quality of sugar beet as affected by irrigation intervals, cultivars and potassium fertilization in North Delta. J. Agric. Res. Kafr El-Shiekh Univ., 36(4):361.

Barlog, P., W.Garzebisz, K.Peplinski and W.Szczepaniak, 2013. Sugar beet response to balanced nitrogen fertilization with phosphorus and potassium. Part 1: Dynamics of beet development. Bulgarian J. of Agric. Sci., 19(6): 1311-1315.

Efetha, A., 2012. Irrigation scheduling for sugar beet in Alberta.Agro-Facts.1-4.

El-Sheikh, S.R., K.A. Khaled and S.A. Enan, 2009. Evaluation of some sugar beet varieties under three harvesting dates. J. of Agric. Sci., (Moshtohor), 34(3): 1559-1567.

Enan, S.A., S.R. El-Shiekh and K.A. Khaled, 2009. Evaluation of some sugar beet varieties under different levels of N and Mg fertilization. J. Biol. Chem. Environ. Sci., 4(1): 1-10.

Grzebisz , W., K. Pepliński, W. Szczepaniak, P. Barłóg and K. Cyna, 2012. Impact of nitrogen concentration variability in sugar beet plant organs throughout the growing season on dry matter accumulation patterns. Journal of Elementology, 17: 389-407.

Hussein, M.M., M.M. Shaaban and A.M. El-Saady, 2008. Response of cowpea plants grown under salinity stress to PK-foliar application. American J. of Plant Physiol., 3(2): 81–88.

Hussein, M.M. and H. Sieam, 2012. Yield and water use efficiency of fodder beet responses to NPK fertilization and withholding irrigation. Intr. J. Sci. and Res., # Issue 11: 3117-3126.

Jafornia, B., B.Ghorban, A.Z. Feizabody and A.R.Ghnenii, 2013. Impact of crop density and soil l., 3(2): 81–88.fertilization on sugar beet. Intr J. of Agric. and Crop Sci., 5(24) 2991-2999.

Kandil, A.A., 2016. Responses of some sugar beet varieties under salinity, topotassic fertilizers, towards the rational use of high salinity tolerant plants. .Series: Tasks for Vegetation Science

:199-207.

Marinkovik, B., J.Cemobarac, G. Jacinovic, D. Marinkovik, D.V. Mericov, and M. Rajici, 2008. J. Agric. Res., 40(2): 99-104.

Masri, M.I., B.S.Ramadan, A.M. El-Shafi, and M.S. El-Kady, 2015. Effect of water stress and fertilization on yield and quality of sugar beet under drip and sprinkler irrigation systems in sandy soil. Intr. J. Agric. Sci., 5(3): 414-425.

Neseim, M.R., A.Y. Amin and M.M.S. El-Mohammady, 2014. Effect of potassium applied with foliar spray of yeast on sugar beet growth and yield under drought stress. Global Advanced Research Journal of Agricultural Science, 3(8): 1-12.

Oshea, C.G., B.Lynech, M.Lynch, J.Callan and J.V. O'Doherty, 2009. Ammonia emissions and dry mater separated pig manure fractions as affected by crude protein concentration and sugar beet pulp inclusion in finishing pig diet. Agric. Ecosyst. Environ., 131:154- 164.

Ragab, A.Y. and S.H. Rashed, 2011. Sugar beet yield and quality as affected by water regime before harvest density and some cultivars in new reclaimed soils. Journal of Advances in Agriculture, 6(1): 1-12.0

Seadh, S.E., 2012. Maximum sugar beet yields with decreasing fertilization pollution. Intr. J. of Agric. Sci., 4(7):293-298.

Shaaban, M.M., M.M. Hussein and A.A. El-Saady, 2010. Growth of sugar beet as affected by diluted sea irrigation water and possible enhancement of salinity stress tolerance with MPK foliar fertilization. Fruit, Vegetable and Cereal Science and Biotechnology, 4(1 Special issue):88-92.

Shalaby, N.M.E., A.M.H. Osman and A.H.S.A. El-Labbody, 2011. Evaluation of some sugar beet varieties as affected by harvesting dates under newly reclaimed soil. Egypt. J. of Agric. Res., 89(2): 605-614.

Snedecor. G.W and W.G. Chocran, 1990. Statistical Methods". Iowa state Univ., Iowa, USA

Stevens, W.B., R.D.Violett, S.A. Skalsky and A.O. Mesbah, 2008. Response of Eight Sugar beet Varieties to Increasing Nitrogen Application: I. Root, Sucrose, and Top Yield. J. Sugar Beet Research, 45: 65-83.

Suna , Y., X. Cuia and F.Liub, 2015. Effect of irrigation regimes and phosphorus rates on water and phosphorus use efficiencies in potato. Hort. Sci., 190: 64–69.

Topak , R., S.Suheri and B.Aacr, 2011. Effect of different drip irrigation regimes on sugar beet (*Beta vulgaris* L.) yield, quality and water use efficiency in Middle Anatolian, Turkey. Irrigation Science, 29(1):79-89·