Effect of Surface Irrigation Regimes and Potassium Levels on Growth, Physiological Characters and Productivity of Fodder Beet (*Beta vulgaris*, L.) under Calcareous Soil Conditions

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ABSTRACT

The present investigation was carried out in the farm of Nubaria Agricultural Research. Station during the two winter seasons 2016/2017 and 2017/2018 to study the effect of three surface irrigation treatments (I_1=100%, I_2= 80%, I_3= 60% of ETp) and four potassium levels (control 0, 57.12, 114.24 and 171.36 K_2O/ha) on fodder beet growth, physiological characters, productivity and forage quality under calcareous soil conductions. The main results were as follows:

1- Increasing irrigation levels up to 100% ETp led to significant increase in crop growth rate at the two periods (90-120) and (120-150 DAS), root diameter, leaf area per plant, root dry matter/ plant, root fresh weight/plant, total yield, crude protein percentage, digestive crude protein percentage, shoot K%, crude fiber percent and carbohydrate percent. There was insignificant difference between 100% and 80% ETp in leaves dry matter /plant, foliage fresh weight /plant, foliage yield (ton/ha) and K% in root. Whereas the total digestible nutrient percent and root length were significantly increased by increasing water stress. Medium treatment at 80% of ETp give the maximum values of water use efficiency (WUE).

2- Increasing potassium fertilization levels up to 171.36 kg K_2O/ha significantly increased CGR at (90-120 and 120-150 DAS), root length, root diameter, leaf area, root dry matter /plant, leaves dry matter /plant, CP%, DCP%, CF% and carbohydrate % In root. Adding 171.36 or 114.24 kg K_2O/ha had insignificant differences in the first CGR period (90-120) DAS, root fresh weight (kg/plant), foliage fresh weight (g/plant), K% in shoot and root. TDN (%) decreased by increasing potassium fertilization levels. Maximum water use efficiency (WUE) was obtained when plants received 171.36 kg K_2O/ha.

3- The interaction effect between water regime and potassium fertilization was found to be significant for CGR at the two periods, root length, leaf area/plant, leaves dry matter/plant, root and leaves fresh weight / plant, total yield, root yield, CP%, DCP%, K% in shoot and carbohydrate% in the combined analysis. The maximum value of WUE was obtained when plants were watered by 80% from ETp and received 171.36 kg K_2O/ha.

Keywords: Fodder beet, water stress, potassium levels, physiological, growth characters, forage yield and quality.

INTRODUCTION

Fodder beet (*Beta vulgaris*, L.) is considered as one of the highest productive forage crops, and it is an ideal fodder for highs performance on dairy cows due to its nutritive value and high dry matter yield. Moreover, it is adapted to saline, calcareous soils and requires less water comared with other forage crops. On the other hand, the horizontal expansion of the new reclaimed areas requires the cultivation of crops offering source for satisfying incame to the farmers.

Irrigation is one of the most important factors, which has always played the greatest role in crop production. Water and fertilizers are two manageable inputs. Response to fertilizers dependson the level of available soil water and hence irrigation practices need to be modified to obtain maximum yields of fodder beet.

Hiekal (2008) used two different levels of irrigation water application, 100% and 70% of crop water requirements respectively, to irrigate fodder beet crop in calcareous loamy sand soil. Results, indicated that maximum average fresh yield (roots and tops) was 38.34 ton/fed, obtained by subsurface drip irrigation at 15 cm depth when 100% of water requirements was applied (2387.3 m^3/fed). Bahuri *et al.* (2003) found that fodder beet yield increased by increasing irrigation water and potassium rats. The fresh roots yield increased by 17.1 and 19.8% with increasing applied water from 2300 to 2760 m^3/fed, respectively compared with 1840m^3/fed irrigation treatment. Also, potassium fertilization recorded a significant effect. Plants characterized decrease in water content, osmotic potential and total water potential accompanied by loss of turgor, close of stomata and decrease in growth as well as decrease in photosynthesis process (Abd el Dayem *et al.*, 2007). A common consequence of drought stress an increased production of reactive oxygen species (Ros) such as superoxide radical (O_2), hydrogen peroxide (H_2O_2) and hydroxyl radical (OH). These (Ros) are all toxic (Beyer and Frdovich, 1987) very reactive and cause severe damage to DNA, proteins and lipids (Bird *et al.*, 1983). Decreasing soil water moisture significantly decreased root and leaves dry weight, root yield and total yield (Mofeeda *et al.*, 2019). Also, Sakr *et al.*, (2014) stated that water stress during maturity stage through withholding last, let two or last three irrigation markedly reduced forage yields and its component as well as crude protein (CP%). In contrary, increased total soluble solids (TSS%) and total digestible nutrients (TDN%) were resulted from drought irrigation.

Potassium is one of the essential elements for plant nutrition and photosynthesis, translocation of photosynthates compounds, protein synthesis, control of ionic balance, regulation of plant stomata, water use, activation of plant enzymes and many others processes (Marschner 1995 and Reddya *et al.*, 2004). Numerous studies have shown that application of K fertilizer mitigates the adverse effect of drought on plant growth (Andersen *et al.*, 1992), Sangakkara *et al.*, 2001, Hasan Zadeh *et al.*, 2012, Kassab *et al.*, 2012 and Mofeeda *et al.*, 2019). The main objectives of this study were to test the effect of three surface irrigation treatments and four potassium fertilization levels on fodder beet growth, physiological characters, productivity, quality of forage and water use efficiency under calcareous soils conduction at Nubaria region.

MATERIALS AND METHODS

Two field experiments were conducted in the farm of Nubaria Agric. Res. Station during the two successive winter seasons of 2016/2017 and 2017/2018. The study was aimed to investigate the physiological response of fodder beet variety Voloshenger to water stress (under surface irrigation system) in combination with potassium application rates (control 0, 57.12, 114.24 and 171.36 Kg K_2O/ha) at different levels of water supply. The adopted irrigation regimes were I_1= 100, I_2= 80 and I_3= 60% of the potential evapotranspiration (ETp), these represent optimum level of water supply (wet), moderate (medium) and severe water stress (dry), respectively.

In the two growing seasons, the amount of applied irrigation water was measured by a flow meter and it was calculated according to the following equation:

$$AIW = \frac{ETp}{Ea\,(1-LR)}$$

Where: AIW = applied irrigation water depth (mm).

ETp = Potential evaporation (mm) values obtained by class A pan evaporation method (Doerenbos and Kassam, 1979) and calculated as follows:

$ETp = E_{Pan} \times K_{Pan}$

Where: E_{Pan}= daliy of measured A Pan Evaporation daily values (mm/day).

K_{pan} = Pan Coefficient. K_{Pan} values depend on the relative humidity, wind speed and the site conditions (bare or cultivated). A K_{pan} value of 0.75 was used for the experimental site.

Ea = irrigation efficiency (70% for surface irrigation system under experimental condition).

LR = leaching requirements (no additional water for leaching was added during the two growing seasons due to the low EC values of irrigation water and soil profile.

Water use efficiency (WUE) values were calculated according to Jensen (1983) as follows:

$$WUE = \frac{\text{Fodder beet total yield (kg/ha)}}{\text{applied irrigation water } (m^3/ha)}$$

Total yield = root yield + foliage yield

Seeds of fodder beet, which were obtained from Agricultural Research Centre, were sown on 30/10/2016 and 13/10/2017 in both seasons respectively. Each plat area was $42m^2$ (6x7m) and included 6 ridges, 7 m long, 50 cm a part. All normal cultural practices of growing fodder beet in the location were followed. Phosphorus fertilizer was applied to the soil before sowing at the dose of 71.4 kg P_2O_5/ha in the form of monocalcium superphosphate (15.5% P_2O_5). Potassium treatments were applied at the levels of 0, 57.12, 114.24 and 171.36 kg K_2O/ha and ammonium nitrate (33.5% N) at the rate of 142.8 kg N/ha. The both four levels of potassium and ammonium nitrate were applied in two equal doses at 21and 42 days after sowing.

The experimental design was a split plot in three replications. Irrigation regime were arranged in the main plots, whereas the potassium levels were randomly distributed in the sub-plots. Soil characteristics data of the experimental site are shown in Table (1).

Table 1: Soil characteristics of the experimental site

*** Particle size distribution**	**Value**
Sand (%)	51.4
Silty (%)	24.2
Clay (%)	23.2
Texture	Sandy loam
*** Chemical character**	
Soil reaction pH (1: 2.5)	7.95
Electric conductivity (ds/m)	2.12
Organic matter (%)	0.23
$CaCO_3$ %	18.90
***Available macronutrients (mg/100g)**	
N	35.50
P	2.98
K	120.8
***Available micronutrients (ppm)**	
Fe	4.5
Mn	2.71
Zn	1.46
Cu	1.06

*Ec ds\m: soil paste

Soil organic matter, $CaCO_3$, EC and pH were determined according to Black *et al.* (1982). Particle size distribution and soil moisture characters were determined as described by Blackmore (1972). Soil field'scapacity (FC) and wilting point (WP) of the soil at experimental site were determined on mass basis by a pressure extractor apparatus (LAB 023 LABORATORY). Available soil moisture (ASM) values were calculated and bulk density (BD) values were determined. The obtained results are presented in Table 2.

I. Growth and physiological characters:

To determine some growth traits, five plants were randomly taken from each plot at 90, 120 and 150 days after sowing (DAS). In each sample, plants were separated into their components leaves and roots, then dried at 60°C for 48h in a ventilated oven to a constant weight to determine crop growth rate (CGR) at (90-120) and (120-150) DAS in g/plant/week according to Woston (1952) and calculated as follows:

$$CGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Where $W_2 - W_1$ = differences in dry mater accumulation between two successive samples in grams.

$T_2 - T_1$ = the number of days between two successive samples in weeks. Leaf area per plant (cm^2) was taken after 150 days from sowing (LA= 25.43 x dry weight of leaves per plant /dry weight of leaves disks. At harvesting time root length per plant (cm), root diameter/plant (cm), root dry matter (g/plant) leaves dry matter (g/plant), root fresh weight (kg) and foliage fresh weight (g) were determined.

II. Fodder beet Yields

At harvesting time, 200 days from sowing, each plot was harvested and weighed to determine the following data: total yield (ton/ha), root yield (ton/ha) and foliage yield (ton/ha).

III. Chemical composition

After 160 (DAS): - Crude protein (CP, %) of root was determined according to A.O.A.C. (1990).

Digesting crud Protein (DcP, %) of roots

- DcP: [(CP × 0.9115) – 3.62] was determined according to Mcdonald *et al.* (1978).
- Potassium content (%) of shoot and root: at harvesting time were determined according to Anton *et al.* (1995).

-Crud Fiber (CF%) was determined of root according to A.O.A.C. (1990).

- Total carbohydrate of roots (%) after 160 (DAS): Rroot samples were collected from each plot and dried in oven at 60°C for 48h up to a constant weight, ground and prepared to determine total carbohydrate (%) according to A.O.A.C. (1990).
- Total digestible nutrients (TDN %) in root were calculated according to Church (1979).

Statistical analysis

The obtained data were analyzed with the appropriate method of statistical analysis of variance (ANOVA) as described by Gomez and Gomez (1984) using SAS (2014), and the means were compared using least significant differences (LSD test) at 0.05 level of probability. The combined analysis of variance was performed for the data of the two seasons after performing the test of homogeneity of error by Bartlet's test (Steel and Torrie 1980). The discussion of the results were carried out on the basis of combined analysis for two seasons except water relation.

RESULTS AND DISCUSSION

Growth and Physiological Characters

Crop Growth Rate (CGR)

Data in Table 3 represent the effect of irrigation regimes, i.e. 100, 80 and 60% reference crop evapotranspiration(ETp), corresponding to 0, 57.15, 114.24 and 171.36 kg k_2o/ha. Results show that irrigation regimes,i.e, 100, 80 and 60% reference crop evapotranspiration (ETp) on CGR at the first period (90-120) DAS and the secand period (120-150) DAS recorded a significant effect. It can be noticed the CGR values were higher in the second period than the first period, such finding may be due to plants directed its effort in the second period for accumulate photosynthesiate compounds which increase dry matter accumulation. The maximum values of CGR at the two growth periods under study were obtained under the wet treatment which was watered with amount of water equals 100% of potential evapotranspiration (ETp). However, the minimum values were obtained from dry treatment (I_3) (irrigatied with amount of water equals 60% of potential evapotranspiration (ETp) in combined analysis.

Table 2: Field capacity, wilting point, available water and bulk density for soil of the experimental site at Nubaria Agric. Res. Station farm

Soil depth (cm)	Field capacity (%)	Wilting points (%)	Available water (%)	Bulk density (g/cm^3)
0-15	24.60	13.53	11.07	1.17
15-30	24.70	13.42	11.28	1.20
30-45	23.90	12.99	10.91	1.22
45-60	23.60	12.83	10.77	1.25
Means	24.27	13.19	11.08	1.21

Table 3: Effect of irrigation treatment and potassium levels on CGR (g/plant/week) at 90-120 DAs, 120-150 Das, root length (cm), root diameter (cm) and leaf area (cm^2) in 2016/2017 and 2017/2018 seasons

Irrigation Treatments	CGR (g/plant/week) 90-120 DAS			CGR (g/plant/week) 120-150 DAS			Root length (cm)			Root diameter (cm)			Leaf area (cm^2)		
ETp (%)	S1	S2	Com	S1	S2	com	S1	S2	com	S1	S2	com	S1	S2	com
Control (100% ETp)	7.605^{A}	7.590^{A}	7.590^{A}	16.830^{A}	16.879^{A}	16.850^{A}	49.340^{C}	50.05^{C}	49.690^{C}	39.449^{A}	36.355^{A}	37.90^{A}	5651.0^{A}	5856.5^{A}	5753.75^{A}
80%ETp	7.349^{B}	7.409^{B}	7.380^{B}	15.143^{B}	15.250^{B}	15.200^{B}	52.670^{B}	53.01^{B}	52.840^{B}	36.339^{B}	33.463^{A}	34.90^{B}	5324.8^{B}	5424.75^{B}	5374.75^{B}
60%ETp	6.518^{C}	6.590^{C}	6.554^{C}	13.850^{C}	14.011^{C}	13.930^{C}	56.130^{A}	56.220^{A}	56.170^{A}	27.359^{C}	25.370^{B}	26.36^{C}	4749.4^{C}	4.9321.1^{C}	4840.75^{C}
LSD at 0.05	0.062	0.060	0.037	0.116	0.141	0.076	0.667	0.626	0.410	1.800	2.946	1.424	31.050	24.52	17.68
Potassium levels (kg/ha)															
0	4.847^{D}	4.916^{C}	4.880^{D}	10.880^{D}	10.963^{D}	10.920^{D}	50.672^{D}	50.774^{D}	50.720^{D}	29.633^{D}	27.497^{D}	28.770^{D}	3903^{D}	4205.3^{D}	4054.15^{D}
57.12	6.071^{C}	6.106^{B}	6.09^{C}	13.813^{C}	13.898^{C}	13.860^{C}	51.494^{C}	52.517^{C}	52.280^{C}	32.468^{C}	29.519^{C}	30.990^{C}	4537.8^{C}	4665.2^{C}	4601.5^{C}
114.24	8.788^{B}	8.76^{A}	8.874^{A}	18.005^{B}	18.136^{B}	18.070^{B}	53.031^{D}	53.513^{D}	53.270^{B}	35.967^{B}	32.989^{D}	34.480^{D}	6077.1^{B}	6204^{B}	6140.5^{B}
171.36	8.923^{A}	8.896^{A}	8.91^{A}	18.391^{A}	18.522^{A}	18.460^{A}	55.182^{A}	55.517^{A}	55.350^{A}	39.42^{A}	36.497^{A}	37.960^{A}	6449^{A}	6543^{A}	6496^{A}
L.SD at 0.05	0.055	0.029	0.041	0.058	0.045	0.084	0.389	0.312	0.0476	2.474	3.112	2.790	36.830	18.550	20.840

Where: S_1=2016/2017 season and S_2=2017/2018 season

These results agreed with those reported by Abdallah and Yassen,(2008); Hussein *et al.,* (2011) and Mofeeda *et al.*,(2019).

These finding may be due to the water stress condition have been found to disrupt dry matter accumulation or formation of photosynthesate compounds (Abdo, Fatma and Anton, 2009). Moreover, it was suggested that, at the drought stress level causes cellular shrink age of cells. cell membrane injury and production of free radicals that cause damage to the cellular apparatus (Terbea *et al.*, 1995 and Sgherri *et al.*, 1996). Similar results were obtained by Mary Henan (2011) on sunflower plants.

The effect of potassium fertilization, indicated that adding 171.36 kg K_2O/ha significantly increased (CGR at the second period compered by 114.24 Kg K_2O/ha but no significant at the first period in combined analysis. Such finding was attributed to significant regulatory roles of K, in numerous plant. Physiological process via stomatal regulation, photosynthesis, nutrient balance and dry matter accumulation (Marschner, 2012).

Significant interaction between water treatments and potassium fertilization was recorded for CGR at the two periods under this study in both seasons and combined analysis as shown in Fig 1.

Root length and Diameter (cm)

Results in (Table 3) showed that water deficit increased significantly root length of fodder beet plant. Such results can be explained on the basis that as the upper soil dries, roots may grow deeper searching for water. These results are in line with Miseha *et al.*(1992) and Anton*et al.* (1995), who found that water stress increased root length of fodder beet plant. Table (2) show that increasing soil moisture stress decreased significantly root diameter of fodder beet would be restricted under dry conditions. It's worthy to mention that the fodder beet root which was less in diameter had greater in length. In this connection, Kramer (1969) and Anton *et al.*(1995) concluded that either an excess or a deficiency of soil water, limits root growth and functioning.

Table (3) show that the application of 171.36 kg K_2O/ha increased significantly root length and root diameter. Such results may prove the importance of potassium for those crops which store carbohydrates like fodder beet plant. In other words, data indicated that fodder beet plant need an ample supply of potassium for good growth and high production, Romheld and Kirkby (2010) suggested that, increasing root growth, by applying K increases the root surface area under drought conditions, which ultimately enhances the water uptake by plant cells.

Figure (1) shows, the significant effect of interaction between irrigation treatment and potassium fertilization levels on root length in combined analysis. The highest values of root length were obtained from water stress treatment equal 60% (I3) and received (171.36 kg K_2O/ha).

Leaf area (cm^2)

Data from Table 3 show that leaf area (LA) was significantly affected by soil moisture stress. The wet treatment (I1) 100% of potential evopotranspiration ETP significantly increased leave area in both seasons and the combined analysis. Whereas, dry treatment (60% of ETP (I3) resulted in the lowest values. Such reduction may be due to water deficit which induced a reduction in leaf area. These results are in harmony with those obtained by Saren *et al.* (2004) who found that irrigated sesame by four irrigations significantly increased LA I compared with one, two and three irrigations.

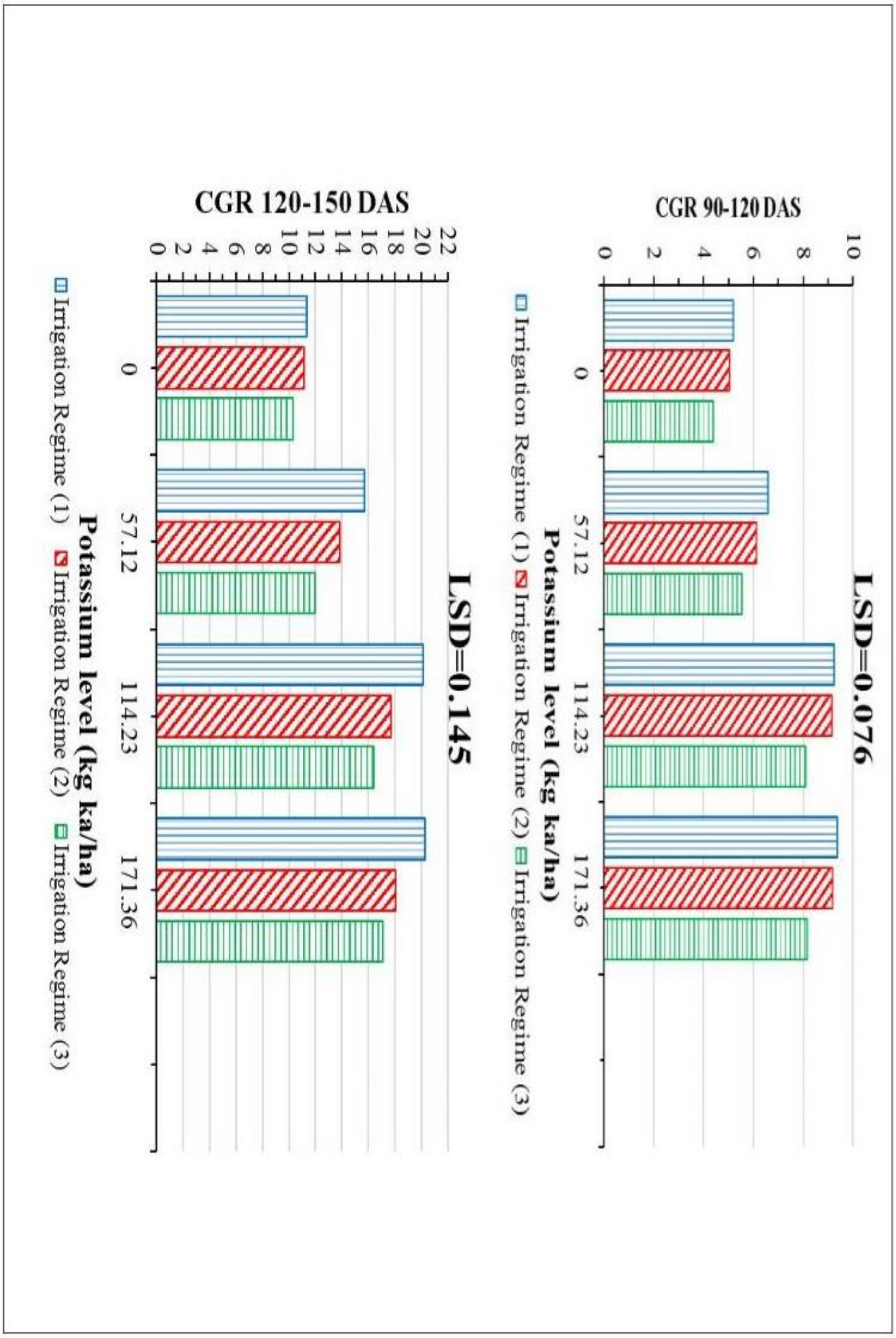
Concerning the effect of potassium fertilization on LA, plants treated with 171.36 kg K_2O/ha had the highest value of LA compared with other potassium treatments. Such finding may be due to the role of potassium in activating at least 60 different enzymes involved in plant growth (Roberd, 2005).

Figure (2) show the significant effect of interaction between water stress and potassium fertilization on LA (cm^2). The maximum values of LA was obtained from plants irrigated at (100% ETP) in combination with adding potassium rate of (171.36 kg K_2O/ha).

Root and leaves dry matter (g/plant)

Results of Table 4 show that water stress significantly decreased root and leaves dry matter/plant as in combined analysis, wherease the 100% (ETP) and 80% (ETP) treatments in leaves dry matter were higher than 60% ETP. Such results may indicate the importance of maintaining soil moisture at a high level for maximum accumulation of roots and leaves dry matter of fodder beet plant. In this respect Stanhill and Cohchron (1967) and Anton *et al.* (1995) concluded that there is a close relationship between decreasing soil water moisture and growth reduction of plant.

Data presented in Table 4 clearly show that the application of 171.36 kg K_2O/ha increased significantly root and leaves dry matter plant in the combined analysis. The application of potassium with 171.36 and114.24 Kg K_2O/ ha had a significant differences on root and leaves dry matter/ plant. Abdel Hamid *et al.* (1992) and Anton *et al.* (1995) stated that foliar application of 400ppm potassium stimulated greatly the accumulation of dry matter in roots and leaves of fodder beet plant. Such result can be explained on the basis that potassium play an important role for accumulation of dry matter in the storage organs of plant. Such result can be explained on the basis that potassium play an important role for accumulation of dry matter in the storage organs of plant.


CGR 90-120 DAS
LSD=0.076
0
2
4
6
8
10
0
57.12
114.23
171.36
Potassium level (kg ka/ha)
Irrigation Regime (1)
Irrigation Regime (2)
Irrigation Regime (3)
CGR 120-150 DAS
LSD=0.145
0
2
4
6
8
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Potassium level (kg ka/ha)
Irrigation Regime (1)
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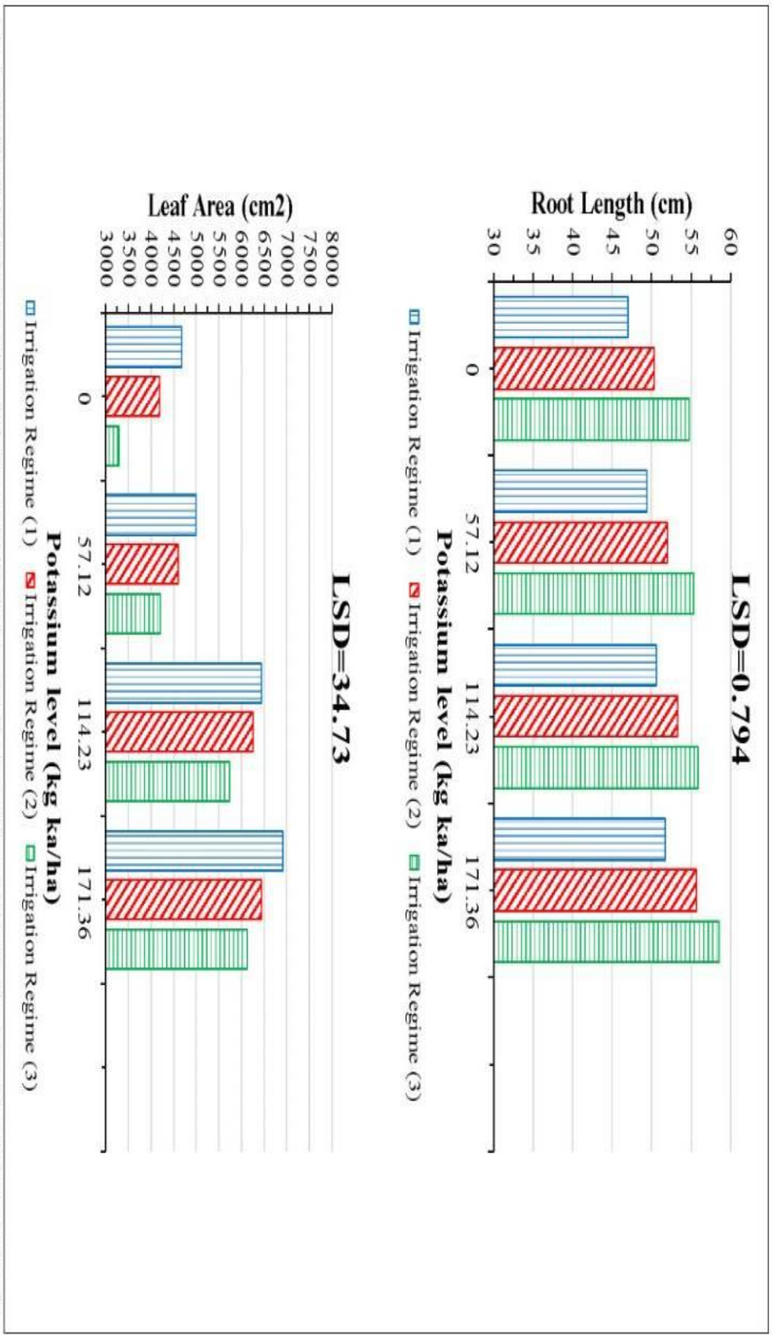


Fig. 1: CGR 90-120 DAS, CGR 120-150 DAS, root length (cm), and leaf area (cm2) as affected by the interaction between irrigation treatments and potassium fertilizer levels combining two seasons

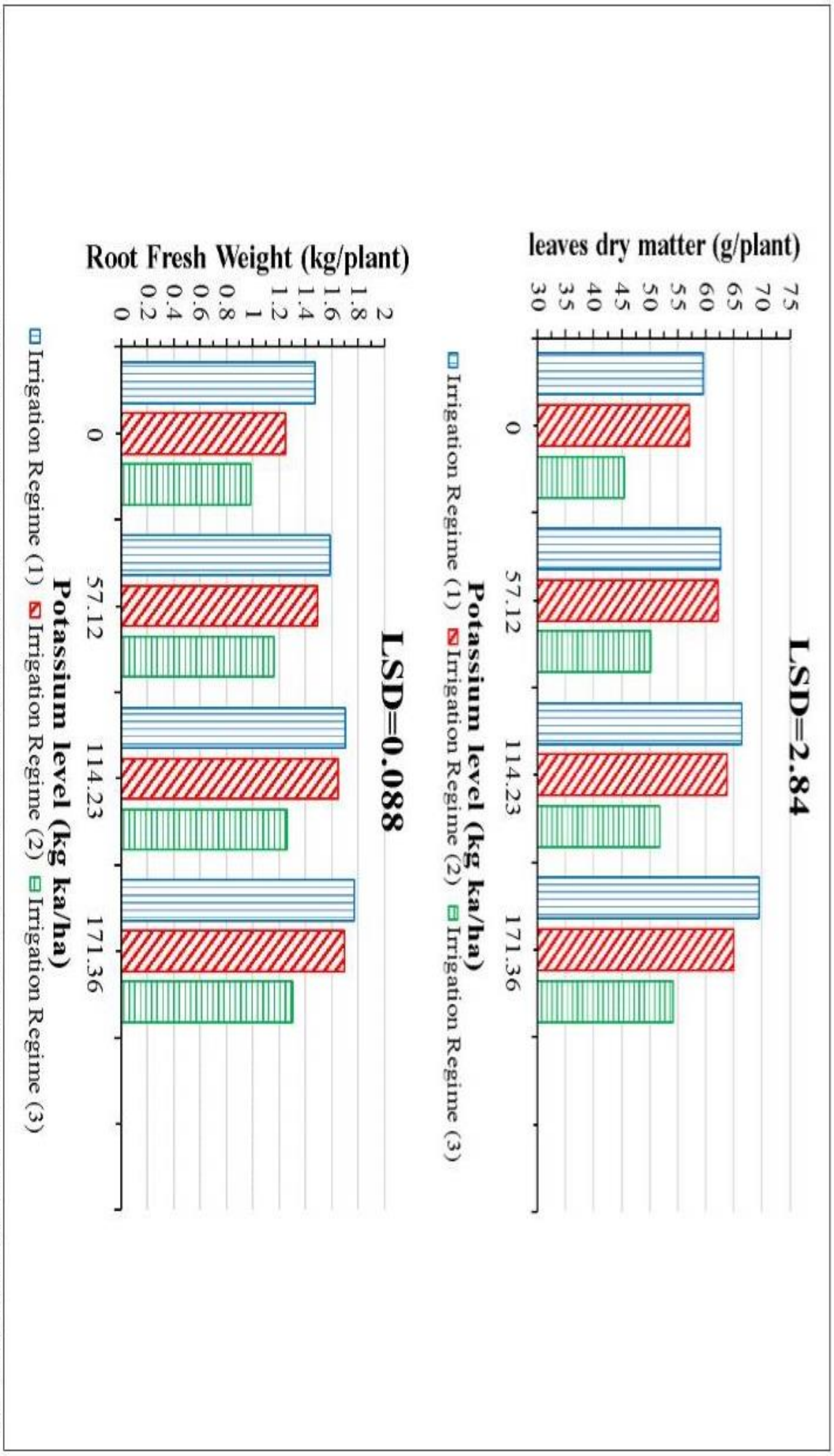


Fig. 2: Leaves dry matter and Root fresh weight as affected by the interaction between irrigation treatments and potassium fertilizer levels combining two seasons

Table 4: Effect of irrigation treatment and potassium levels on root dry matter (g/plant), leaves dry matter (g/plant), root fresh weight (kg/plant) and foliage fresh weight (g/plant)

Irrigation Treatments	Root dry Matter (g/plant)			Leaves dry matter (g/plant)			Root fresh weight (kg/plant)			Foliage fresh weight (g/plant)		
ETp (%)	2013/2014	2014/2015	Com	S1	S2	Com	S1	S2	Com	S1	S2	Com
Control (100% ETp)	254.049^{A}	262.089^{A}	258.010^{a}	64.600^{A}	64.399^{A}	64.530^{a}	1.605^{a}	1.663^{a}	1.634^{a}	424.281^{a}	422.080^{a}	423.180^{a}
80% ETp	234.013^{B}	236.528^{B}	235.270^{b}	61.734^{B}	62.521^{A}	62.130^{b}	1.503^{b}	1.5328^{b}	1.520^{b}	417.485^{a}	414.744^{a}	416.110^{a}
60% ETp	192.823^{C}	198.315^{C}	195.570^{c}	50.577^{C}	50.266^{B}	50.410^{c}	1.163^{C}	1.192^{C}	1.180^{c}	372.662^{b}	371.429^{b}	372.040^{b}
LSD at 0.05	11.521	12.441	8.190	2.535	2.721	1.297	0.094	0.042	0.041	15.667	16.181	9.554
Potassium levels (kg/ha)												
0	188.081^{D}	187.504^{c}	187.790^{c}	54.059^{D}	53.959^{c}	54.01^{D}	1.204^{c}	1.266^{c}	1.235^{c}	377.25^{c}	372.362^{c}	374.890^{c}
57.12	224.720^{C}	227.728^{b}	226.220^{b}	58.126^{c}	58.579^{b}	58.35^{c}	1.407^{b}	1.420^{b}	1.410^{b}	398.892^{b}	402.089^{b}	400.490^{b}
114.24	241.375^{b}	253.564^{a}	247.470^{b}	60.355^{b}	61.001^{a}	60.68^{b}	1.516^{a}	1.561^{a}	1.540^{a}	413.926^{a}	412.452^{a}	413.190^{a}
171.36	253.672^{a}	260.483^{a}	257.080^{a}	63.420^{a}	62.709^{a}	63.06^{a}	1.569^{a}	1.610^{a}	1.590^{a}	428.994^{a}	424.182^{a}	426.590^{a}
L.SD at 0.05	11.011	12.142	9.369^{a}	1.828	2.303	1.704	0.092	0.051	0.053	14.532	15.212	17.140

Where: S_1=2016/2017 season and S_2=2017/2018 season

Data in Fig. 2 show that the interaction effect had insignificant effect on root dry matter/plant in but it was significant effect on leaves dry matter/plant. The maximum value of leaves dry matter/plant were obtained from plants irrigated at (100% ETP) in combination with added (171.36 kg K_2O/ha).

Root and Foliage fresh weight (g/ plant)

Data in Table 4 showed that root and leaves fresh weight (kg/plant) decreased with increasing soil water moisture stress from 100% up to 60% ETP. On the reverse data indicated that the plants growing under (100%) ETP and 80% of potential evapotranspiration ETP were obtained higher values compared to 60% ETP, respectively without significant differences between two treatments in foliage weight (g/plant). Foyer and Noctor (2000) stated that drought stress inhibited photosynthetic activity in tissues due to the deficiency of water; one of the main factor in photosynthesis activity.

Concerning the effect of potassium fertilization on root and foliage fresh weight, plants treated with 171.36 and 114.24 kg K_2O/ha had the highest value compared with other potassium treatments and without any significant differences between such two treatments. In this concern (Mofeeda *et al.*, 2019), Tang *et al.*(2015) pointed that K indispensable mineral constituent, intrinsically playing a key role in plant growth and development process.

The interaction between water stress and potassium fertilization on root and leaves dry matter (g/plant) was found to be significant. There was no significant between plants irrigated with 100% (wet treatment) in combination with adding 171.36 and 114.24 kg K_2O/ha as shown in Fig. 2.

Fodder beet Yields

Data shown in Table 5 contain the effect of irrigation regimes; i.e. 100%, 80% and 60% reference crop evapotranspiration (ETP) on Fodder beet yields in combined analysis. Decreasing water amounts (water stress) led to substantial decreases in the aforementioned yield parameters. The present results showed root yield and total yield significantly affected by irrigation treatment in combined analysis. The maximum value was obtained when plants irrigated with amount of water 100% of ET_P (54.81 ton/ha) and (65.70 ton/ha) in combined analysis followed by irrigation treatment with amount of water equal 80% of (ET_P). On the other hand there was insignificant differences between such two treatments for foliage yield (ton/ha) in combined analysis. The results reported here in this investigation coincided those previously obtained by Drawucatt and Messem (1977) and Mofeeda *et al.* (2019). Tagmetto *et al.* (2003) found that plots irrigated with surface drip irrigation produced the highest sugar beet yield, but furrow irrigation produced the lowest one.

However, Isoda *et al.* (2007) found that the irrigation led to an increase in the beet sugar yield due to an increase in the root yield. There was a slight reduction in the sugar content in roots. Human *et al.* (1990) and Hall *et al.* (1990) pointed out response to water stress conditions decrease to water stress conditions decrease photosynthesis and respiration.

As for the effect of potassium fertilization results indicated that applying 171.36 kg K_2O/ha significantly increased total yield (ton/ha) and root yield (ton/ ha) compared with other potassium treatments. No significant differences were observed between such treatment 171.36 kg K_2o/ ha and added 114.24 kg K_2O/ha with respect to foliage yield (ton/ha). These results could be ascribed to the enhanced effect of potassium on fodder beat growth which resulted in turn higher yield and its components. Tandon (1990) explained such results that potassium involves in the activation of large number of enzymes in the production and translocation of photosynthates compoineds from source to sink. These results are in harmony with those obtained by Mofeeda *et al.* (2019).

Also, the improvement of increasing potassium fertilization levels may be ascribed to the vital regulatory functions of potassium in photosynthesis process, photosynthesis translocation, improving the osmotic adjustment as well as activation of plant enzymes and antioxidant defense system (Sakr *et al.*, 2014 and Hasanuzzaman *et al.*, 2018 and Mofeeda *et al.*, 2019).

Data in Fig.3 show the interaction effect between soil moisture stress and potassium fertilization was found to be significantly affected on total yield (ton/ha) and root yield (ton/ha). However, the maximum values of fodder beet yields were obtained when plants irrigated with amount of water equal 100%and (80%) of ETP in combination with 171.36 (kg K_2O/ha), respectively in the combined data.

Chemical characters

Tables 6 and 7 show that, CP%، DCP% of root, K% in shoot, CF and carbohydrate (%) of root were significantly increased under wet conditions at (100%ETP). On the other hand, plant irrigated plants wit (60%ETP) give the highest value of (TDN%). While, increasing water deficit to 80% ETP(medium treatment) in significantly decreased K% in root at harvesting time. El-Kalla *et al.*(1985) explained the carbohydrates reduction under water stress conditions, that water shortage causes stomatal closure and this in turn prevents CO_2 diffusion into the air inside the tissue of plants and consequently the photosynthetic efficiency becomes low.

Table 5: Effect of irrigation treatments and potassium levels on total yield (tan/ha), root yield (ton/ha) and foliage yield (ton/ha) in 2016/2017 and2017/2018 seasons

Irrigation Treatments	Total yield (ton/ha)			Root yield (ton/ha)			Foliage yield (ton/ha)		
ETp (%)	S1	S2	com	S1	S2	com	S1	S2	Com
Control (100% ETp)	64.541^{A}	66.862^{A}	65.701^{A}	53.491^{A}	56.129^{A}	54.810^{A}	10.049^{a}	10.733^{a}	10.391^{a}
80% ETp	60.645^{B}	62.715^{B}	61.680^{B}	51.262^{B}	52.769^{B}	52.015^{B}	9.383^{a}	9.946^{a}	9.664^{a}
60% ETp	94.789^{C}	45.512^{C}	45.150^{C}	37.537^{C}	36.697^{C}	37.117^{C}	7.253^{b}	8.816^{b}	8.034^{b}
LSD at 0.05	1.341	2.722	2.582	2.106	2.532	3.082	1.190	1.201	1.746
Potassium levels (kg/ha)									
0	48.031^{D}	51.486^{D}	49.758^{D}	40.090^{d}	43.030^{d}	41.560 d	7.940^{C}	8.456^{C}	8.198^{C}
57.12	54.539^{C}	55.287^{C}	54.913^{C}	46.044^{C}	45.790^{C}	54.917c	8.494^{b}	9.497^{b}	8.995^{b}
114.24	58.498^{B}	60.403^{B}	59.450^{B}	49.308^{B}	49.893^{B}	49.600b	9.190^{A}	10.509^{A}	9.849^{A}
171.36	64.233^{A}	66.278^{A}	65.255^{A}	54.278^{A}	55.414^{A}	54.1846^{a}	9.955^{A}	10.864^{A}	10.409^{A}
L.SD at 0.05	1.266	2.004	0.981	1.890	1.114	0.901	0.933	0.910	0.563

Where: S_1=2016/2017 season and S_2=2017/2018 season

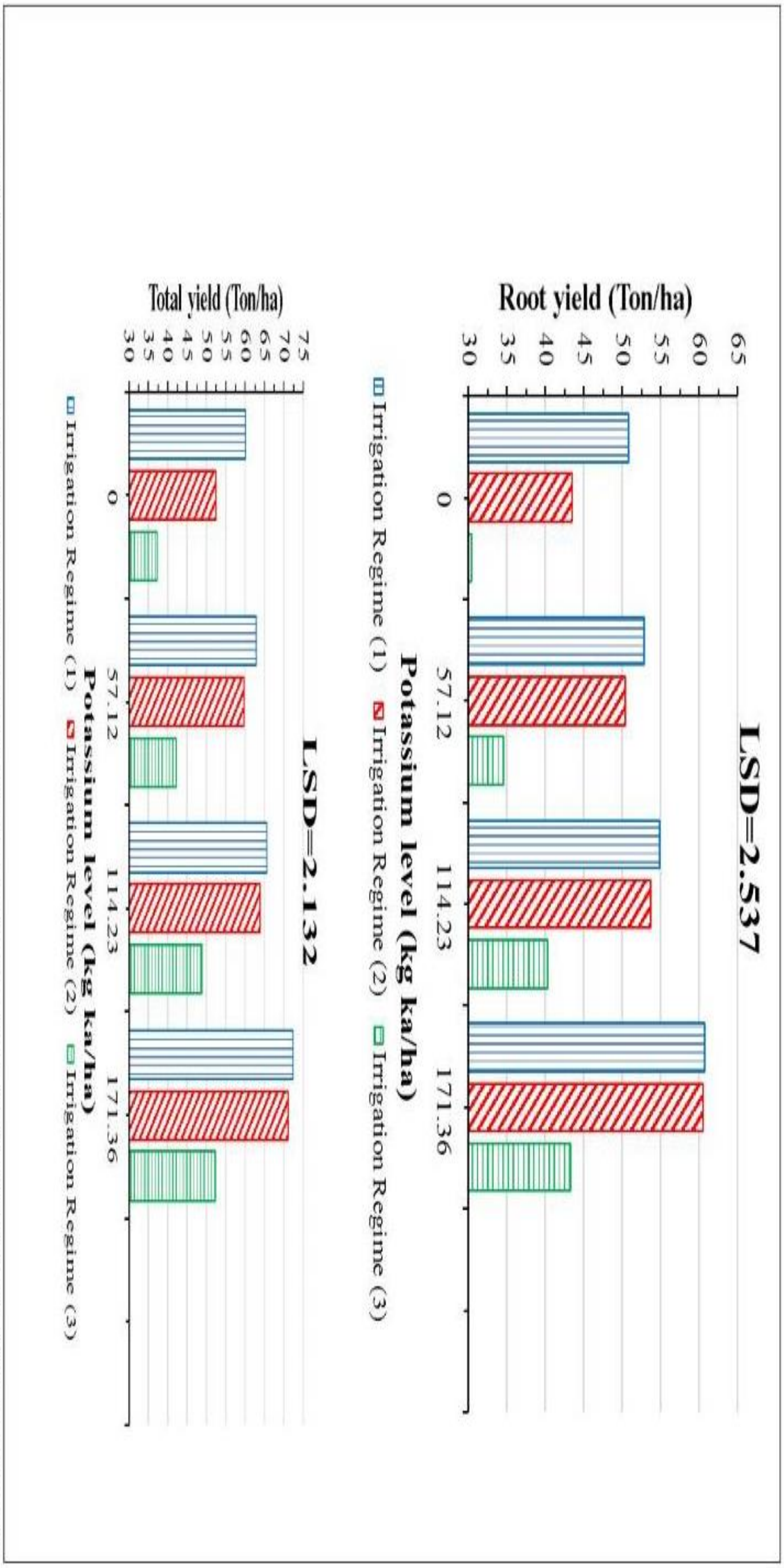


Fig. 3: Root yield (ton/ha) and Total yield (ton/ha)as affected by the interaction between irrigation treatments and potassium fertilizer levels combining two seasons

Table 6: Effect of irrigation treatments and potassium levels on crude protein (CP%), digesting crude protein (DCP%) of roots, K% shoot and K% root in 2016/2017 and 2017/2018 seasons

Irrigation Treatments	CP % of root			DCP % of root			K% Shoot			K% Root		
ETp (%)	S1	S2	com	S1	S2	com	S1	S2	com	S1	S2	Com
Control (100% ETp)	7.045^a	6.355^a	6.690^a	3.064^a	2.380^a	2.722^a	3.197^a	3.595^a	3.396^a	0.360^a	0.330^a	0.345^a
80% ETp	5.529^b	5.652^b	5.591^b	1.656^b	1.771^b	1.713^b	2.450^b	2.826^b	2.638^b	0.312^a	0.302^a	0.307^a
60% ETp	5.016^c	5.098^c	5.057^c	1.179^c	1.256^c	1.217^c	2.210^c	2.447^c	2.328^c	0.267^b	0.267^b	0.267^b
LSD at 0.05	0.301	0. 427	0.219	0.330	0.412	0.223	0.342	0.242	0.175	0.049	0.036	0.039
Potassium levels (kg/ha)												
0	4.772^D	4.784^D	4.778^D	0.953^D	0.964^D	0.958^D	2.0486^C	3.176^C	2.831^c	0.270^C	0.240^C	0.255^c
57.12	5.658^C	5.405^C	5.531^c	1.776^C	1.541^C	1.658^c	2.510^b	3.165^b	2.837^b	0.310^b	0.290^b	0.300^b
114.24	6.330^b	5.983^b	6.156^b	2.400^b	2.077^b	2.238^b	2.683^a	2.963^a	2.823^a	0.333^a	0.320^a	0.326^a
171.36	6.692^a	6.609^a	6.650^a	2.737^a	2.659^a	2.698^a	2.696^a	2.620^a	2.658^a	0.350^a	0.350^a	0.350^a
L.SD at 0.05	0.239	0.314	0.276	0.313	0.329	0.321	0.093	0.097	0.095	0.025	0.036	0.031

Where: S_1=2016/2017 season and S_2=2017/2018 season

Table 7: Effect of irrigation treatments and potassium levels on crude fiber (CF%), carbohydrate (%) and total digestible nutrients (TDN%) of root hn 2016/2017 and2017/2018 seasons.

Irrigation Treatments	CF (%) of root			Carbohydrate (%) of root			TDN (%) of root		
ETp (%)	S1	S2	com	S1	S2	com	S1	S2	com
Control (100% ETp)	7.870^a	7.677^a	7.774^a	69.962^a	68.687^a	69.324^a	85.632^c	85.595^c	85.613^c
80% ETp	6.889^b	6.867^b	5.878^b	66.855^b	67.307^b	67.081^b	86.039^b	86.093^b	86.066^b
60% ETp	5.495^c	5.0582	5.276^c	64.965^c	60.142^c	62.553^c	87.088^a	87.488^a	87.288^a
LSD at 0.05	0.139	0.166	0.105	0.887	0.962	0.554	0.513	0.562	0.323
Potassium levels (kg/ha)									
0	6.266^d	5.922^d	6.094^d	59.280^d	59.566^d	59.423^d	86.351^a	86.655^a	86.503^a
57.12	6.607^c	6.245^c	6.426^c	65.073^c	64.233^c	64.653^c	86.318^a	86.600^a	86.459^a
114.24	6.947^b	6.860^b	6.903^b	71.373^b	67.113^b	69.243^b	86.221^b	86.195^b	86.208^b
171.36	7.185^a	7.111^a	7.148^a	73.316^a	69.936^a	71.626^a	86.121^b	86.161^b	86.141^b
L.SD at 0.05	0.113	0.148	0.079	0.635	0.736	0.535	0.071	0.086	0.0768

Where: S_1=2016/2017 season and S_2=2017/2018 season

Similar results were obtained by Anton and El Raies (2000), who found that increasing soil moisture stress up to 70-75%.in sandy soils decreased total carbohydrates of sesame seeds.

Concerning the effect of potassium fertilization, Table 7 indicated that treated fodder beet plants by 171.36 Kg K_2o/ha significantly increased CP%, DCP%, CF% of root and carbohydrate% compared with all potassium levels but, there was insignificant increased K% in shoot, root at harvesting time and TDN (%) between such treatment and 114.24 Kg K_2o/ha. These finding maybe due to the role of potassium in enzymes activation involved in ATP production which is more important to regulating the rote of photosynthesis, sugar formation and translocation. These reported by Thakur and Patel (2003), Abdel-Aziz and El-Bialy (2004) and Mofeeda *et al.* (2019).

Fig. 4 indicated that the interaction effect between soil moisture stress and potassium fertilization recorded was significant effect on CP%, DCP% in root, K% in shoot and carbohydrate in root. The highest value of such traits were recorded from wet treatment (irrigated at 100 ETp) in combination with adding 171.36 and 114.24 kg K_2O/ha, respectively. However, plants growth under dry treatment (60% ETP) recorded highest value of TDN% combination with control and 57.12 kg K_2O/ha,

Soil water relations:

Potential evapotranspiration (ETp)

Monthly potential evapotranspiration (ETp) values measured by class A pan method are presented in Table 8. Results showed that daily (ETp) values were low during December and January and increased to maximum values during May of both seasons.

Amount of applied irrigation water (AIW)

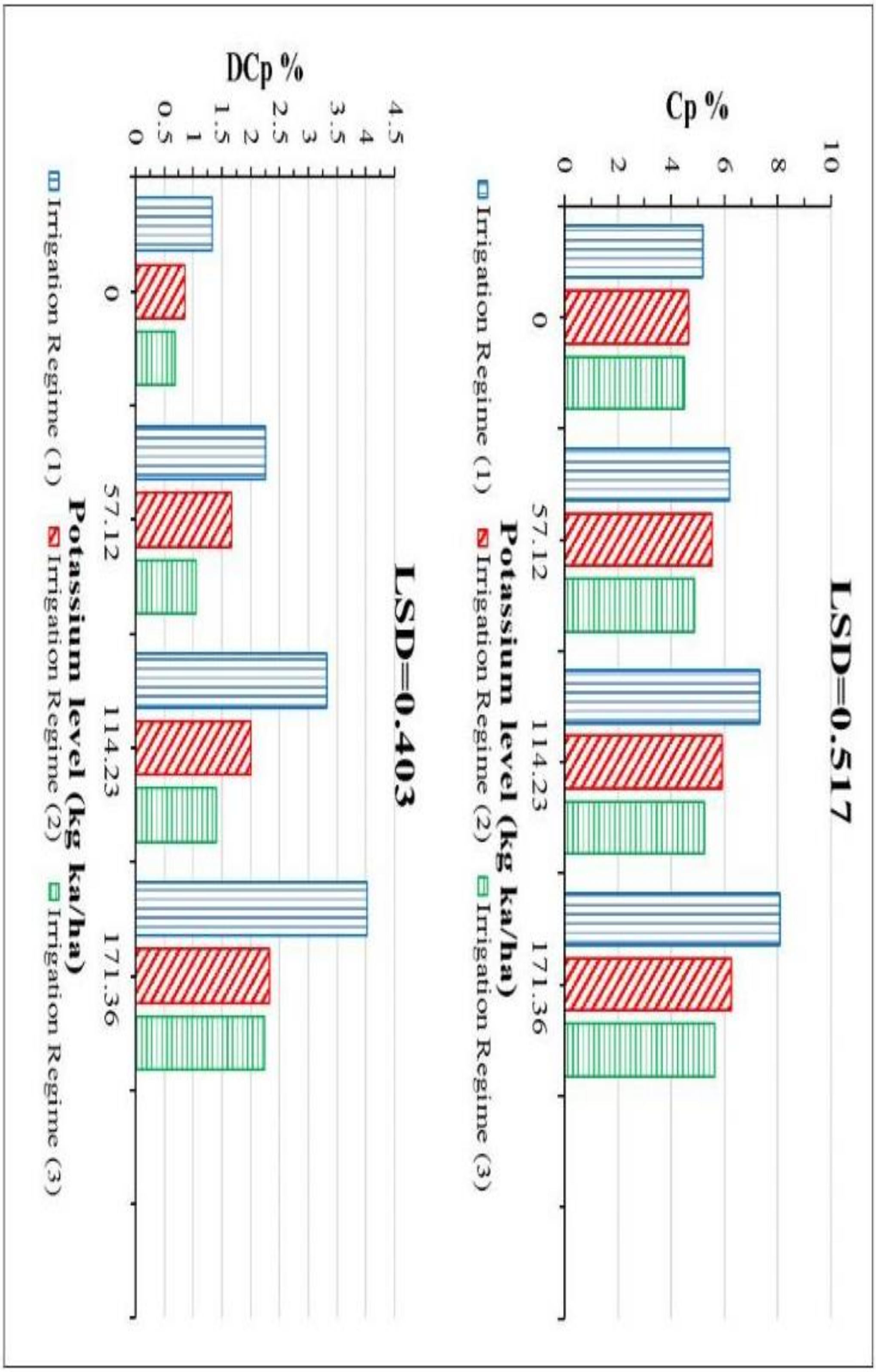
Monthly and total applied of irrigation water by surface irrigation system to the fodder beet according to the different irrigation treatments for two growing seasons are presented in Table 9.

Table 8: Potential evapotranspiration, ETp (mm/day) and (mm/month) during the two growing seasons

Month	2016/2017		2017/2018	
	mm/month	mm/day	mm/month	mm/day
Oct.	--	--	48.45	2.85
Nov.	44.32	1.47	54.00	1.80
Dec.	34.87	1.12	41.85	1.35
Jan.	29.06	0.93	34.87	1.12
Feb.	33.71	1.16	41.32	1.42
Mar.	54.09	18.80	67.42	2.17
Apr.	81.00	2.70	101.25	3.37
May	99.45	3.31	121.50	4.05
Jun	53.43	3.56	--	--
Total	429.93		510.66	

Table 9: Amounts of applied irrigation water (mm, m^3/fed. and m^3/ha) as affected by irrigation treatments

Months	2016/2017 Irrigation treatments			2017/2018 Irrigation treatments		
	100%ETp	80%ETp	60%ETp	100%ETp	80%ETp	60%ETp
Oct.	--	--	--	69.21	69.21	69.21
Nov.	63.31	63.31	63.31	77.14	61.71	46.28
Dec	49.81	39.84	29.88	59.78	47.82	35.86
Jan.	41.51	33.20	24.90	49.81	39.84	29.88
Feb.	48.15	38.52	28.89	59.02	47.21	35.41
Mar.	77.27	61.81	46.36	96.31	77.04	57.78
Apr.	115.51	92.56	69.42	144.64	115.71	86.78
May	142.27	113.65	85.24	173.57	138.85	104.14
Jun.	76.32	61.05	45.79	--	--	--
Total (mm)	614.15	503.94	393.79	729.48	597.39	465.34
m^3/fed	2579.43	2116.54	1653.91	3063.81	2509.03	1954.42
m^3/ha	6139.04	5037.36	3936.30	7291.86	5971.49	4651.51


LSD=0.517
Cp %
Potassium level (kg ka/ha)
Irrigation Regime (1)
Irrigation Regime (2)
Irrigation Regime (3)
LSD=0.403
DCp %
Potassium level (kg ka/ha)
Irrigation Regime (1)
Irrigation Regime (2)
Irrigation Regime (3)

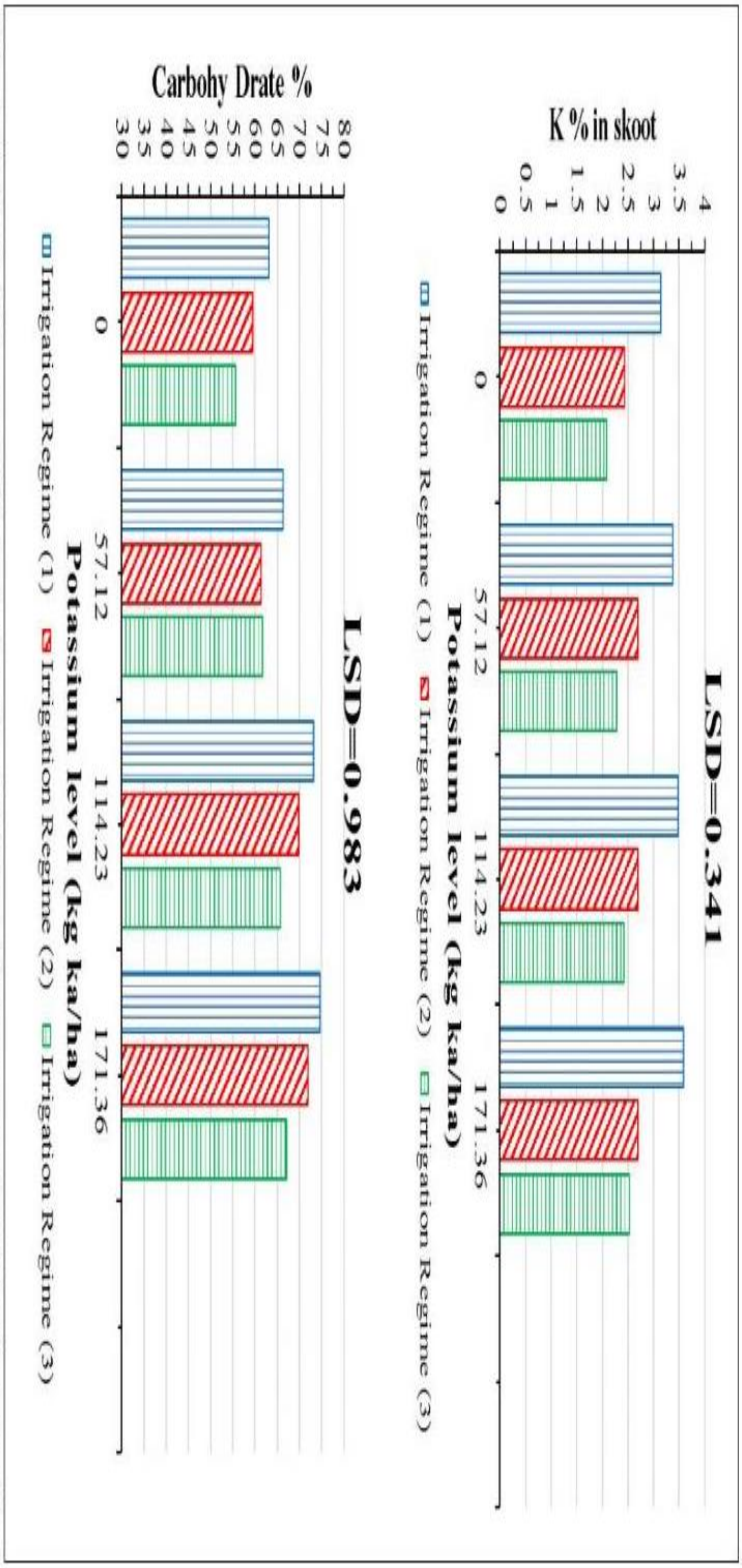


Fig. 4: Cp%, Dcp% in root, K% in shoot and carbohydrate % in root as affected by the interaction between irrigation treatments and potassium fertilizer levels combining two seasons

Results showed that the total amount of applied irrigation water for 100, 80 and 60% of ETp irrigation treatments were 6139.04, 5037.36 and 3936.30m^3/ha in the first season, while they were 7291.86, 5971.49 and 4651.51 m^3/ha in the second season, respectively. Differences in the amount of applied irrigation water between the two successive seasons due to differences in climatic conditions. Results showed the normal trend of increasing applied irrigation water with the advance in plant growth and decrease at the ripening stage. The obtained results agreed with those of Doorenbos and Kassam (1979) and Bahuri *et al.* (2003).

Water use efficiency (WUE):

The effect of surface irrigation regime and Potassium treatments on water utilization efficiency as Kg of fodder beet total yield per cubicmeter of applied water per ha during the two growing seasons is presented in Table10.

The results showed that WUE values were 10.34, 12.08 and 11.37Kg in the first season and they were 9.16, 10.50 and 9.77 kg fodder beet total yield in the second season for irrigation treatments I_1, I_2 and I_3, respectively.

It is clear from the results that WUE values from first season were higher than those from the second season due to less amount of applied irrigation water was added in the first season. The reduction in WUE value for I_1 irrigation treatment as compared to that for I_3 indicates decrease in water use efficiency with increasing applied irrigation water for I_1.

Also, the results indicated that the values of WUE increased with increasing the rate of potassium fertilization for all irrigation treatments in the two growing seasons.

The results also, showed that higher WUtE values were obtained from interaction of I_2 and potassium fertilizer rate (171.36 kg K_2O/ha) in both seasons. The highest value of WUtE recorded 13.78 and 12.18 kg fodder beet total yield/m^3 applied water were obtained from I_2 irrigation treatment and from potassium fertilizer rate (171.36 kg K_2O/ha) in the two growing seasons, respectively.

The results are in agreement with these reported by Doorenbos and Kassam (1979). Results agree also with those of Kassab et al. (2012) who showed that water use efficiency of fodder beet plants increased significantly by decreasing the irrigation level (water stress). Foliar K spray of 1 kg/fed, gave the highest values of growth and yield parameters as well as WUE in both seasons.

CONCLUSION

In the light of the present results, it clearly that the maximum fodder beet yield and quality were obtained from wet treatment (irrigated with 100% ETp) plus potassium fertilization level of 171.36 kg/K_2O/ha followed by medium treatment (80% ETp) and the same level of potassium fertilization.

On the other hand, the maximum value of WUE (kg total yield/m^3 applied water) was obtained under I_2 (80% ETp) and potassium fertilization level of 171.3 kg/ha.

Table 10: Mean water utilization efficiency (WUE) values for fodder beet as affected by irrigation treatments and potassium levels during two growing seasons

Irrigation Treatments	WUE		
	Potassium levels kg/ha	2016/2017	2017/2018
100% ETp (I_1)	0	9.51	8.47
	57.12	10.13	8.77
	114.24	10.43	9.20
	171.36	11.42	10.22
Mean		10.34	9.16
80% ETp (I_2)	0	10.25	8.93
	57.12	11.77	10.07
	114.24	12.54	10.82
	171.36	13.78	12.18
Mean		12.08	10.50
60% ETp (I_3)	0	8.90	8.46
	57.12	10.85	8.95
	114.24	12.26	10.62
	171.36	13.49	11.08
Mean		11.37	9.77
General mean of Potassium fertilization	0	9.55	8.62
	57.12	10.92	9.26
	114.24	11.74	10.21
	171.36	12.90	11.16

Therefore, under calcareous soil condition and surface irrigation regimes of 80% ETp in combination with adding 171.36 Kg K_2o/ha it is recommended that about 20% of amounts applied irrigation water could be saved with insignificant decreasing in total fodder beet yield.

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الملخص العربى

تأثير بعض معدلات الري السطحي ومستويات التسميد البوتاسي على النمو والصفات الفسيولوجية وإنتاجية محصول بنجر العلف تحت ظروف الأراضي الجيرية

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أجريت تجربة حقلية بمزرعة محطة البحوث الزراعية بالنوبارية خلال موسمي ٢٠١٣/٢٠١٤، ٢٠١٤/٢٠١٥ لدراسة الاستجابة الفسيولوجية لبنجر العلف لثلاث مستويات من الري السطحي (١٠٠%، ٨٠%، ٦٠% من البخر نتح)، وأربع مستويات من التسميد البوتاسي بمعدل صفر، ٥٧,١٢، ١١٤,٢٤، ١٧١,٣٦ كيلوجرام أكسيد بوتسيوم /هكتار، وأوضحت النتائج الآتي:

- أدى الري عند ١٠٠% من البخر نتح إلى زيادة معنوية في معدل نمو المحصول في المرحلة الأولى، والثانية على التوالي وقطر الجذر، مساحة الأوراق، والوزن الأخضر للجذر والمحصول الكلي (طن/هكتار)، ومحصول الجذر (طن/ هكتار) ونسبة البروتين الخام والبروتين المهضوم والبوتاسيوم في المجموع الخضري ونسبة الألياف وكذلك نسبة الكربوهيدرات.
- لم تظهر فروق معنوية عند الري بكمية مياه تعادل ١٠٠%، ٨٠% من جهة البخر نتج في الوزن الجاف للأوراقوزن العرش (طن/هكتار) وكذلك نسبة البوتاسيوم في الجذور.

أظهرت النتائج أن مستويات التسميد البوتاسي كانت له تأثير معنوي على محصول بنجر العلف حيث أن معاملة التسميد بمعدل ١١٧,٣٦ كيلوجرام اكسيد بوتاسيوم/ هكتار أعطت أعلى محصول ٦٤,٢٣٣، ٦٦,٢٧٤ طن/هكتار في السنتين على التوالي وكذلك لوحظ زيادة معنوية في معدل نمو المحصول في المرحلتين، طول الجذر، قطر الجذر، مساحة الأوراق، الوزن الجاف للأوراق والجذر وكذلك في صفات جودة المحصول. ولكن لم تظهر فروق معنوية من معاملتي التسميد بمعدل ١٧١,٣٦، ١١٤,٢٤ كجم أكسيد البوتاسيوم/هكتار في معدل نمو المحصول خلال المرحلة الأولى والوزن الأخضر للجذر والعرش ونسبة البوتاسيوم في الجذور والأوراق.

وقد وجد ان كفاءة استخدام الماء تصل لاعلي قيمة لها ١٢,٠٨و١٠,٥٠. عند معاملة النباتات ب ٨٠% من البخر نتح.

- وإن أعلى كفاءة لاستخدام الماء الري كان عند معدل تسميد ١٧١,٣٦ بقيمة ١٢,٩٠، ١١,١٦ كجم بنجر العلف/متر٣.
- وجدت أن كفاءة استخدام وحدة المياه المضافة تزيد بزيادة كمية المياه المضافة حتى ٨٠% من البخر نتح وتصل لأقصى كمية ١٣,٧٨، ١٢,١٨ كيلوجرام لبنجر العلف/متر٣ من المياه في السنة الأولى والثانية على التوالي، مع التسميد البوتاسي بمعدل ١٧١,٣٦كجم/هكتار.

وتشير هذه النتائج أنه تحت ظروف الأراضي الجيرية والري السطحي نوصي بإمكانية خفض ٢٠% من كمية المياه المضافة عند الري ب٨٠% من البخر نتح والتسميد البوتاسي بمعدل ١٧١,٣٦ كجم/هكتار بدون نقص معنوي في محصول بنجر العلف.