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INFLUENCE OF IRRIGATION WITHHOLDING AND POTASSIUM LEVELS ON FORAGE YIELDS AND ITS QUALITY OF FODDER BEET

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Abstract- Water deficit is the most important environmental factors greatly limiting crop production worldwide. A field experiment was carried out to study the effect of irrigation withholding treatments *i.e.* control treatment (7 irrigations), withholding last, last two and last three irrigations (6, 5 and 4 irrigations, respectively), potassium levels (0, 24, 48 and 72 kg K_2O/fed) and their interaction on forage yields, yield components and chemical constituents of fodder beet cv. Voroshenger. Water stress during maturity stage through withholding last, last two or last three irrigations markedly reduced forage yields and its components as well as crude protein (CP%), crude fiber (CF%), potassium (K%), digestible crude protein (DCP%). In contrary, gradual increases in total soluble solids (TSS%) and total digestible nutrients (TDN%) were resulted from irrigation withholding treatments. Increasing potassium level up to 72 kg K_2O/fed produced highest forage yields and its components as well as CP%, CF%, K%, DCP%. Wile, without potassium fertilization was recorded highest TDN%. Water consumptive use values were 49.46, 42.75, 37.1, and 35.58 for irrigation withholding treatments, respectively. Average of crop coefficient (Kc) was 0.97 and water use efficiency (WUE) was 17.25 Kg/m^3 for withholding last irrigation treatment. It could be recommended that withholding the last irrigation (6 irrigations) and compensated the reduction in forage yields through fertilizing with 48 kg K_2O, which overtook the treatment by most fodder beet farmers (7 irrigations without potassium fertilization) under the environmental conditions of El-Serw district, Damietta Governorate, Egypt.

Keywords- Fodder beet, Irrigation withholding, Water stress, Water consumptive use, Water use efficiency, Crop coefficient, Potassium levels.

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Introduction

Fodder beet (*Beta vulgaris* L.) is one of the most promising winter forage crop in Egypt especially under limited water and nutrients levels. All parts of fodder beet plant (foliage and roots) used in animal feeding, whether directly or processed as silage. The advantages of using fodder beet in animal feeding include; high dry matter yield, good source of carbohydrates in dairy cows meal (about 72% DM), high palatability and digestibility. Moreover, it produced economic yield (25-30 t/fed) in marginal lands as arid regions [1]. So, its cultivation may help in overcoming the problem of animal feeding in Egypt during summer season.

In Egypt, agriculture is expected to face less and less water availabilities in the near future. During maturity stage and root formation of fodder beet, plants are subjected to some unfavorable conditions such as low winter rainfall, shortage of water irrigation, this may affect growth and yield. Great attention has been given to irrigation efficiency during the last decades aimed to saving water through irrigation withholding. Water stress caused decrease in osmotic potential and total water potential as well as water content which accompanied by loss of turgor cells consequently closure of stomata and decrease in growth as well as decrease in the photosynthesis process [2]. Also, water stress increased production of reactive oxygen species, which are toxic [3] and very reactive and cause severe damage to DNA, proteins and lipids [4].

Several studies carried out to determine the effect of water stress on growth and yield of fodder beet, in this concern; Abdallah & Yassen [1] studied the effect of water saving by using three irrigation intervals 14, 21 and 28 days on fodder beet yield. They showed that increasing water stress by extension of irrigation to 21 and 28 days significantly reduced foliage fresh and dry weights/plant and root length, whereas root diameter were not significantly affected by irrigation augmentation. Ahmed [5] revealed that water stress by prolonging irrigation interval from 8 up to 24 days reduced foliage dry weight/plant, root volume, roots fresh and dry weights, crude protein, total carbohydrate and potassium in roots. On the other hand, crude fiber in roots of fodder beet increased as the irrigation interval extended to 24 days. Kassab, et al [6] indicated that increasing irrigation level (100% of reference crop evapotranspiration) led to significant increases in all growth and yield characters. While water use efficiency of fodder beet plants increased significantly by decreasing the irrigation level (50% of reference crop evapotranspiration). El-Sarag [7] reported that irrigating fodder beet plants with 100% soil field capacity gave the highest fresh and dry foliage and root yields. Although, irrigated when soil field capacity reached 75% produced economic forage yields.

The response of a plant to environmental stress is determined by its nutritional status. Improving plant tolerance to drought is achieved by applying potassium which seems to have beneficial effects in overcoming soil moisture stress. In addition, potassium plays a vital role in; photosynthesis process, photosynthates translocation, synthesis of protein, ionic balance control, plant stomata regulation [8] and water use as well as activation of plant enzymes [9,10]. Potassium is not only an essential macronutrient for plant growth and development, but also mitigates the adverse effects of moisture stress in plants by increasing translocation and maintaining water balance within plants [11]. Therefore, plants growing under drought conditions accumulating abundant potassium in their tissues may play an important role in water uptake and increased abscisic acid (ABA) levels which stimulates the release of potassium from guard cells, giving rise to stomatal closure [12]. Numerous studies have shown that potassium fertilizer mitigates the adverse effects of drought on plant growth. In this regard, Ahmed [5] showed that potassium application (150 kg K_2O/fed) increased fresh and dry weights of roots and foliage/plant, root volume, yields of roots and foliage/fed, crude protein, total carbohydrate and potassium in roots as compared with the control (nil potassium). Crude fiber percentage in roots of fodder beet decreased with increasing potassium fertilizer from 0 up to 150 kg K_2O/ fed. Kassab, et al [6] reported that potassium application at 1 kg/fed as foliar addition increased enzymes activities and tolerance to oxidative damage and improved cell membrane of fodder beet plants grown under water regime.

Therefore, the objective of this study was to find out the effects of irrigation withholding treatments and potassium fertilizer levels on forage yields and its components as well as quality of fodder beet cv. Voroshenger under the environmental conditions of El-Serw district, Damietta Governorate.

Materials and Methods

Two field experiments were carried out at the Experimental Research Station in El-Serw, Agricultural Research Center (ARC) during 2011/2012 and 2012/2013 seasons to study the effect of irrigation withholding treatments and potassium fertilizer levels and their interaction on forage yields and its components as well as chemical constituents of fodder beet (*Beta vulgaris* L.) cv. Voroshenger. The studied fodder beet cultivar was introduced from Hungary by Forage Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.

A strip-plot design with three replications was used. Each experiment included sixteen treatments comprising, four irrigation treatments and four potassium fertilizer levels in both seasons. The vertical plots were assigned to four irrigation treatments as follows; control treatment (giving plants 7 irrigations), withholding last irrigation (giving plants 6 irrigations), withholding last two irrigations (giving plants 5 irrigations) and withholding last three irrigations (giving plants 4 irrigations). The horizontal plots were occupied with four potassium fertilizer levels (0, 24, 48 and 72 kg K_2O/fed) as soil addition. Potassium fertilizer in the form of potassium sulfate (48% K_2O) was applied as a side-dressing in two equal doses before first and second irrigations.

The soil of experimental site has clayey in texture and its physical and chemical properties were shown in [Table-1] and [Table-2]. The preceding summer crop was rice (*Oryza sativa* L.) in the two growing seasons.

Table 1- Some physical and chemical properties of the experimental sites as average of soil depth 0-60 cm during 2011/2012 and 2012/2013 seasons.

Properties Seasons	Sand %	Silt %	Clay %	$CaCo_3$ %	EC ds m^{-1}	pH %	OM %	Total N (%)	Available (mg/kg)	
									P	K
2011/2012	11.79	22.26	65.95	1.34	7.7	8	0.86	0.84	7.51	210.2
2012/2013	12.23	21.67	66.1	1.41	7.75	8.01	0.75	0.95	7.92	215.6

Table 2- Soil field capacity, wilting point, available water and bulk density at different soil depth (cm) of the experimental sites as the averages of both seasons.

Soil depth (cm)	Field capacity (% mass)	Wilting point (% mass)	Available water (% mass)	Bulk density (g/cm^3)
0-15	48.43	26.31	22.12	1.11
15-30	45.58	24.77	20.21	1.2
30-45	46.99	25.53	21.46	1.23
45-60	42.86	23.29	19.57	1.11
Average	45.96	24.97	20.84	1.16

Each experimental basic unit included 10 ridges, each of 60 cm apart and 7.0 m length, comprising an area of 42 m^2 (1/100 fed). The experimental field well prepared and then divided into the experimental units. Calcium superphosphate at 150 kg/fed (15.5% P_2O_5) was applied during soil preparation.

Sowing took place on 5th and 6thNovember in the first and second seasons, respectively. Fodder beet was hand sown 3-5 balls/hill using dry sowing method on one side of the ridge in hills 25 cm apart. Plants were thinned at the age of 30 days from sowing to obtain one plant/hill (28000 plants/fed). Nitrogen in forms of ammonium nitrate (33.5%) was applied at the rate of 100 kg N/fed in two equal doses, the first was applied after thinning (30 days from sowing) and the second had done before the third irrigation (60 days from sowing). The common agricultural practices for growing fodder beet according to the recommendations of Ministry of Agriculture were followed, except factors under study.

Studied Characters

At maturity (after 202 days from sowing) five guarded plants were pulled up from the outer ridges of each plot to determine yield components characters as follows:

- Root fresh weight (kg/plant).
- Root dry weight (g/plant).
- Foliage fresh weight (g/plant).
- Foliage dry weight (g/plant)
- Root length (cm).

Root volume (cm^3) was determined by putting the fodder beet roots in the given volume of water then measures the displacement (cm^3).

At harvest, plants that produced from the five inner ridges of each plot were collected and cleaned. Roots and foliage were separated and weighted in kilograms, then converted to estimate root and foliage yields (t/fed).

Chemical Constituents

Total soluble solids (TSS%) in roots. It was measured in juice of five random samples of fresh roots by using Hand Refractometer.

Random samples of roots were chopped into 1-2 cm pieces and thoroughly mixed. A 300 g sample of fresh chopped roots was dried in a oven at 40°C for 2 days and at 70°C for 3 days. The dried samples were chemically analyzed for crude protein (CP%) and crude fiber (CF%) as following the methods of AOAC [13]. Potassium content in roots was determined using flame photometer as described by Peterburgski [14]. Digestible crude protein (DCP%) and total digestible nutrients (TDN%) were calculated according to Church [15] by using the following equations:

DCP% = CP% × 0.929 – 3.48

TDN% = 90.36 – (0.29 × CP – 0.86 × CF)

Water Parameters

Gravimetric soil samples at 0.15 m intervals to a depth of 0.60 m were collected after sowing, before and after each irrigation and at harvest time to determine the amount of applied water at each irrigation and the actual evapotranspiration (ET_a) values. The ET_a values for the soil profile were calculated according to the equation given by Israelson & Hansen [16] as follows:

$$ETa = \sum_{i=1}^{n=4} \frac{(\theta 2 - \theta 1)}{100} \times Pb \times D\ (cm)$$

Where:

ET_a= actual evapotranspiration (cm).

i= soil layer.

n= total number of soil layer.

2= (%) soil moisture on mass basis after irrigation.

1= (%) soil moisture on mass basis before irrigation.

b= soil bulk density.

D= layer depth (cm).

Water use efficiency values (WUE) were calculated according to relation given by Jensen [17] as follows:

$$WUE = \frac{\text{Total root yield (Kg/fed)}}{\text{Total water consume (cubic meter)}}$$

Where:

Fodder beet crop efficiency (Kc) values at El-Serw for the growing seasons were calculated the following relation:

$$Kc = \frac{ETa}{Eto}$$

Where:

ET_a = actual evapotranspiration (water consumptive use).

ET_o = potential evapotranspiration.

The measured ET_o values at the experimental site by the class A pan according to Doorenbos & Kassam [18].

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip-plot design as described by Gomez & Gomez [19] using MSTAT statistical package (MSTAT-C with MGRAPH version 2.10, Crop and Soil Sciences Department, Michigan State University, USA). Least Significant Difference (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Snedecor & Cochran [20].

Results and Discussion

Forage Yields and Its Components

Irrigation withholding treatments *i.e.* control treatment (giving plants 7 irrigations), withholding last irrigation (giving plants 6 irrigations), withholding last two irrigations (giving plants 5 irrigations) and withholding last three irrigations (giving plants 4 irrigations) significantly affected root fresh and dry weights, foliage fresh and dry weights, root length and volume [Table-3], root and foliage yields/fed [Table-4] in both seasons. Giving fodder beet plants 7 irrigations (control treatment) was associated with the highest values of all studied forage yields and its components with significant differences as compared with withholding last, last two and last three irrigations in both seasons. Intensive water stress during maturity stage and root formation of fodder beet (withholding last three irrigations) led to a reduction in forage yields and its components which resulted in the lowest values of these characters in the two growing seasons. The reduction in forage yields and its components due to water stress especially during maturity stage and root formation might have been due to decrease in water content and total water potential as well as osmotic potential that accompanied by defeat of cells turgidity, close up of stomata and reduce in growth as well as decrease in the photosynthesis process [2]. Similar results were reported by Abdallah & Yassen [1], Ahmed [5], Kassab, et al [6] and El-Sarag [7].

Forage yields and its components significantly affected by increasing potassium fertilizer levels from 0 to 24, 48 and 72 kg K_2O/fed in both seasons as shown from results in [Table-3] and [Table-4]. Increasing potassium fertilizer level up to 72 kg K_2O/fed produced the highest values of forage yields and its components followed by fertilizing with 48 kg K_2O/fed without significant differences with respect foliage dry weight (in the first season), root length (in both seasons) and foliage yield (in the second season). While, control treatment (without potassium fertilizer) gave the lowest values of these characters. This improvement in forage yields and its components due to increasing potassium fertilizer levels may be ascribed to the role of potassium in photosynthesis process, photosynthates translocation, synthesis of protein, regulation of plant stomata [8], control of ionic balance [11] and water use as well as activation of plant enzymes [10]. These results are in line with those stated by Ahmed [5] and Kassab, et al [6].

There was significant effect due to the interaction between irrigation treatments and potassium fertilizer levels on root fresh weight, root dry weight, foliage fresh weight, foliage dry weight, root volume, root yield/fed and foliage yield/fed in both seasons as shown from results in [Table-3] and [Table-4]. The highest values of root fresh weight [Fig-1], root dry weight [Fig-2], foliage fresh weight [Fig-3], foliage dry weight [Fig-4], root volume [Fig-5], root yield/fed [Fig-6] and foliage yield/fed [Fig-7] were obtained from the control treatment (giving fodder beet plants 7 irrigations) in addition the highest level of potassium fertilizer level (72 kg K_2O/fed) in both seasons. Our results showed that withholding last irrigation (giving fodder beet plants 6 irrigations) and fertilizing with 48 kg K_2O/fed markedly increased all forage yields and its components compared with control treatment for most farmers (giving fodder beet plants 7 irrigations without potassium fertilization) as shown from results graphically illustrated in [Fig-1] to [Fig-7] in the two growing seasons.

Table 3- Root fresh and dry weights, foliage fresh and dry weights, root length and volume as affected by irrigation withholding treatments and potassium fertilizer levels as well as their interaction during 2011/2012 and 2012/2013 seasons.

Characters	Root fresh weight (kg/plant)		Root dry weight (g/plant)		Foliage fresh weight (g/plant)		Foliage dry weight (g/plant)		Root length (cm)		Root volume (cm^3)	
Seasons	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
A- Irrigation withholding treatments												
Control (7 irrigations)	1.848	1.904	289.3	249.25	292.9	277	43.61	42.24	43.2	41.3	1933.3	1825
Withholding last irrigation (6 irrigations)	1.025	1.188	154	170.25	217	216.6	29.52	28.7	34	34	1154.1	883.3
Withholding last two irrigations (5 irrigations)	1.055	1.001	150.2	162.33	188.7	178.7	25.36	24.28	32.5	33.4	914.1	881.6
Withholding last three irrigations (4 irrigations)	0.979	0.712	144.3	107.5	126.2	125.8	20.83	19.91	31.4	32.5	675	825.8
LSD at 5%	0.125	0.084	13	10.5	17.6	13.2	2.25	1.97	3.4	3.2	113.6	114.89
B- Potassium fertilizer levels												
0 kg K_2O/fed	1.024	0.915	153.4	132.5	165	166.8	26.99	26.44	33.1	33	937.5	830.8
24 kg K_2O/fed	1.176	1.095	174.4	157.25	207.5	194.4	29.12	27.74	35.5	35.5	1062.5	1142.5
48 kg K_2O/fed	1.257	1.305	189.7	187.08	210.4	202	31.02	28.73	35.8	36	1291.6	1150.8
72 kg K_2O/fed	1.45	1.49	220.3	212.5	242	235	32.19	32.22	36.6	36.7	1385	1291.6
LSD at5 %	0.117	0.078	12.1	10.1	20.3	14.2	2.15	2.03	1.9	1.7	110.6	139.97
C- Interaction:	*	*	*	*	*	*	*	*	NS	NS	*	*

Table 4- Root and foliage yields/fed, total soluble solids (TSS), crude protein (CP), crude fiber (CF), potassium (K), digestible crude protein (DCP) and total digestible nutrients (TDN) percentages as affected by irrigation withholding treatments and potassium fertilizer levels as well as their interaction during 2011/2012 and 2012/2013 seasons.

Characters	Root yield (t/fed)		Foliage yield (t/fed)		TSS%		CP%		CF%		K%		DCP%		TDN%	
Seasons	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
A- Irrigation withholding treatments																
Control (7 irrigations)	31.069	31.323	3.871	3.877	10.7	13.04	8.44	8.53	8.05	8.06	5.09	5.2	4.36	4.45	80.98	80.94
Withholding last irrigation (6 irrigations)	27.777	27.175	3.54	3.454	11.16	13.62	8.25	8.45	7.94	7.96	4.9	5	4.19	4.37	81.13	81.05
Withholding last two irrigations (5 irrigations)	21.392	21.956	3.272	2.708	10.66	12.04	5.07	5.24	7.84	7.84	4.38	4.47	1.23	1.39	82.14	82.09
Withholding last three irrigations (4 irrigations)	15.304	16.927	2.616	2.407	14.5	15.25	4.94	5.1	6.61	6.66	3.83	3.95	1.11	1.26	83.23	83.14
LSD at 5%	0.446	0.357	0.217	0.203	1.92	1.28	0.24	0.14	0.02	0.02	0.24	0.22	0.22	0.13	0.06	0.04
B- Potassium fertilizer levels																
0 kg K_2O/fed	22.329	22.365	3	2.73	12.25	14	5.75	5.89	7.56	7.59	3.34	3.45	1.86	1.99	82.19	82.11
24 kg K_2O/fed	23.303	23.551	3.319	3.059	12.04	13.62	6.46	6.55	7.59	7.61	4.29	4.4	2.52	2.61	81.95	81.9
48 kg K_2O/fed	24.315	25.441	3.364	3.266	11.7	13.25	7.08	7.25	7.62	7.64	5.22	5.32	3.1	3.26	81.74	81.68
72 kg K_2O/fed	25.595	26.024	3.615	3.391	11.04	13.08	7.43	7.63	7.66	7.67	5.35	5.46	3.42	3.61	81.61	81.54
LSD at 5%	0.363	0.285	0.209	0.155	NS	NS	0.12	0.14	0.01	0.01	0.16	0.17	0.11	0.13	0.04	0.04
C- Interaction:	*	*	*	*	NS	NS	*	*	*	*	NS	NS	*	*	*	*

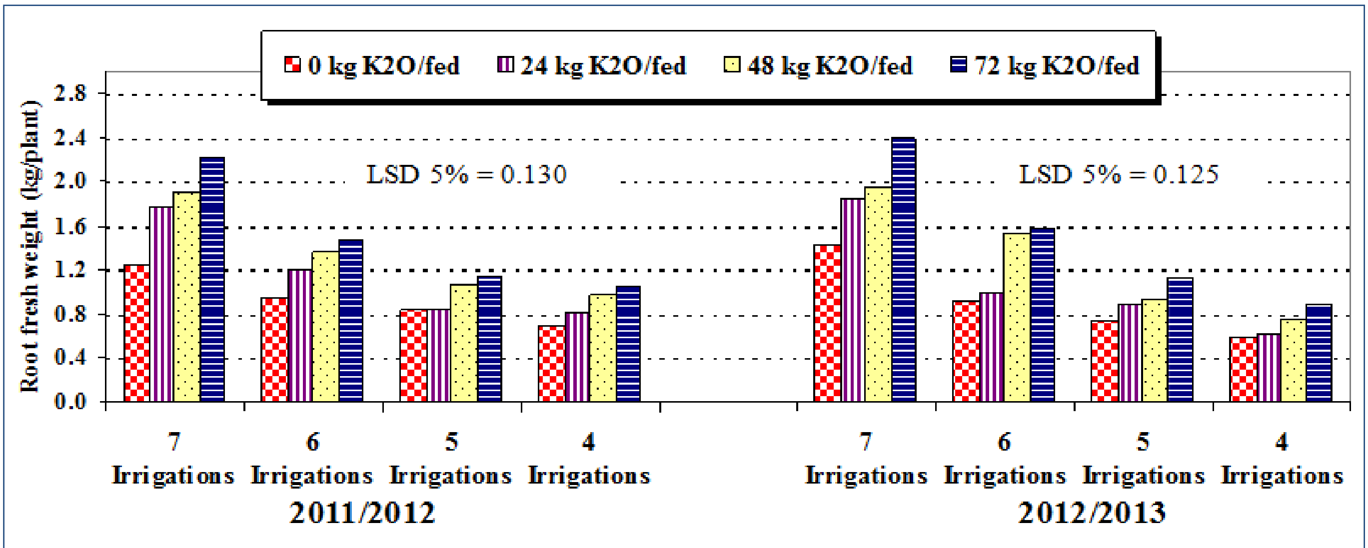

Fig. 1- Root fresh weight (kg/plant) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

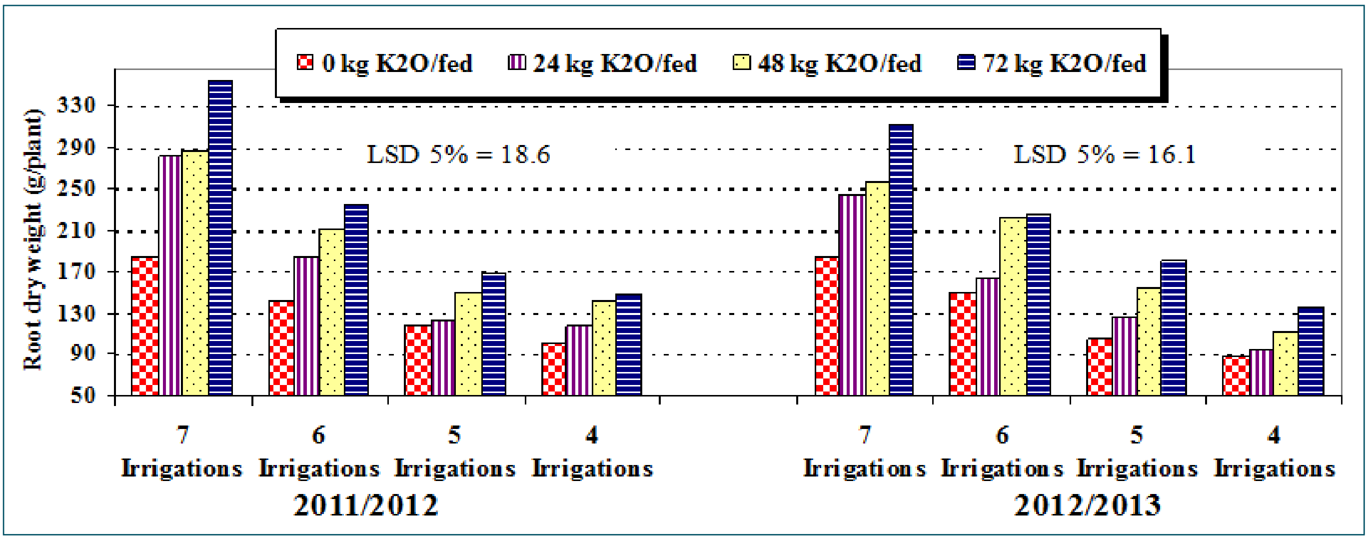

Fig. 2- Root dry weight (g/plant) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons

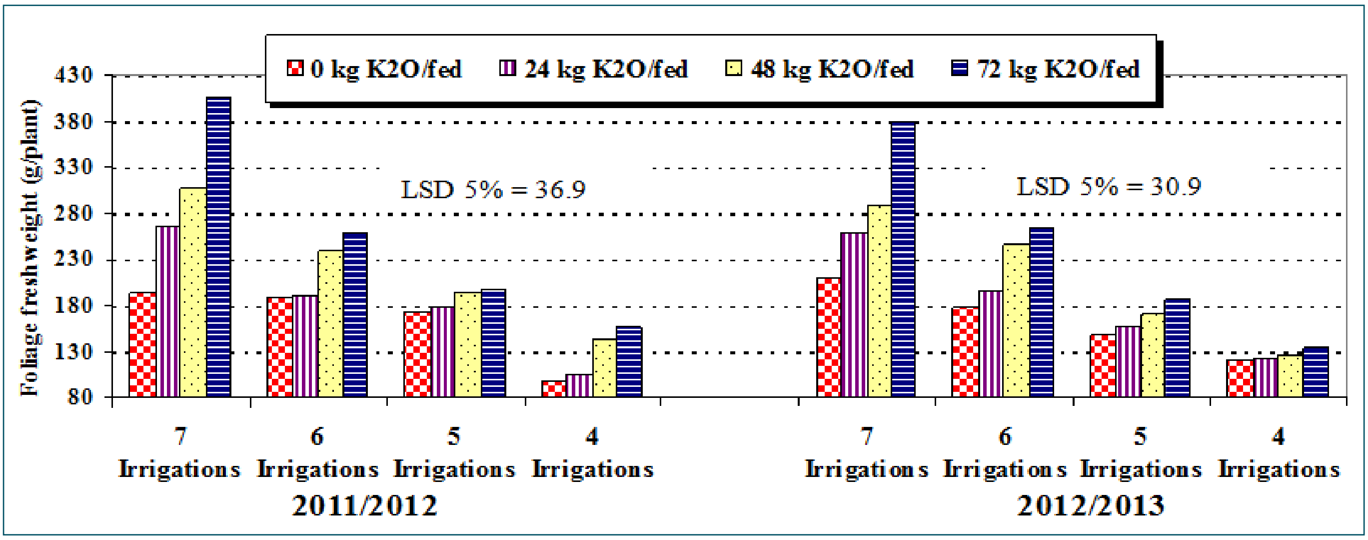

Fig. 3- Foliage fresh weight (g/plant) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

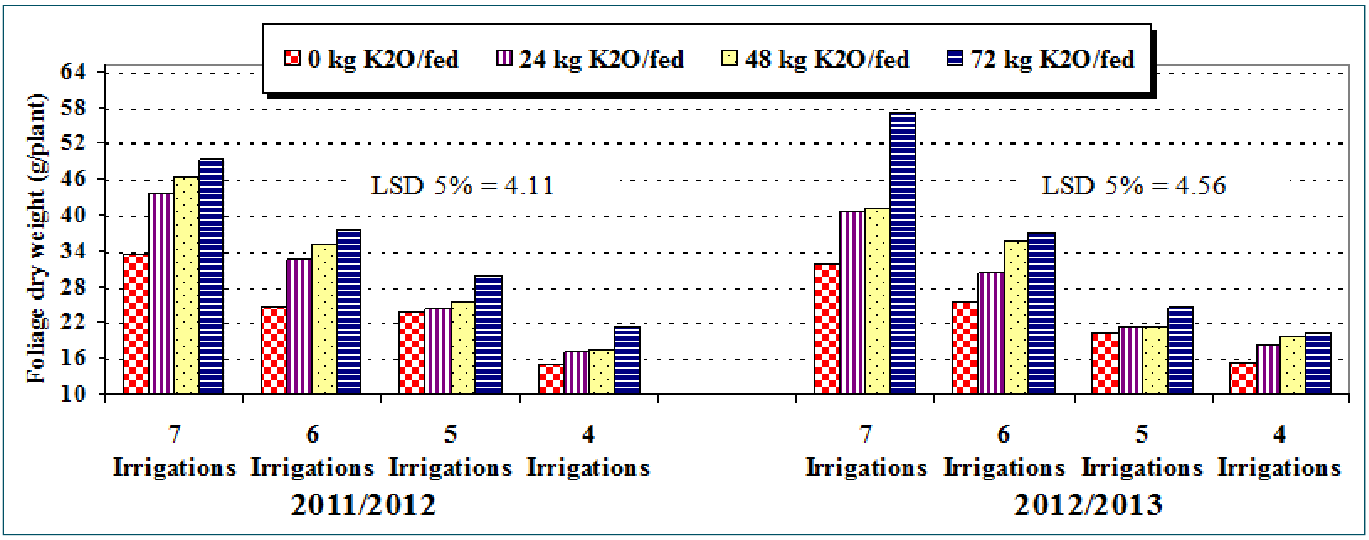

Fig. 4- Foliage dry weight (g/plant) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

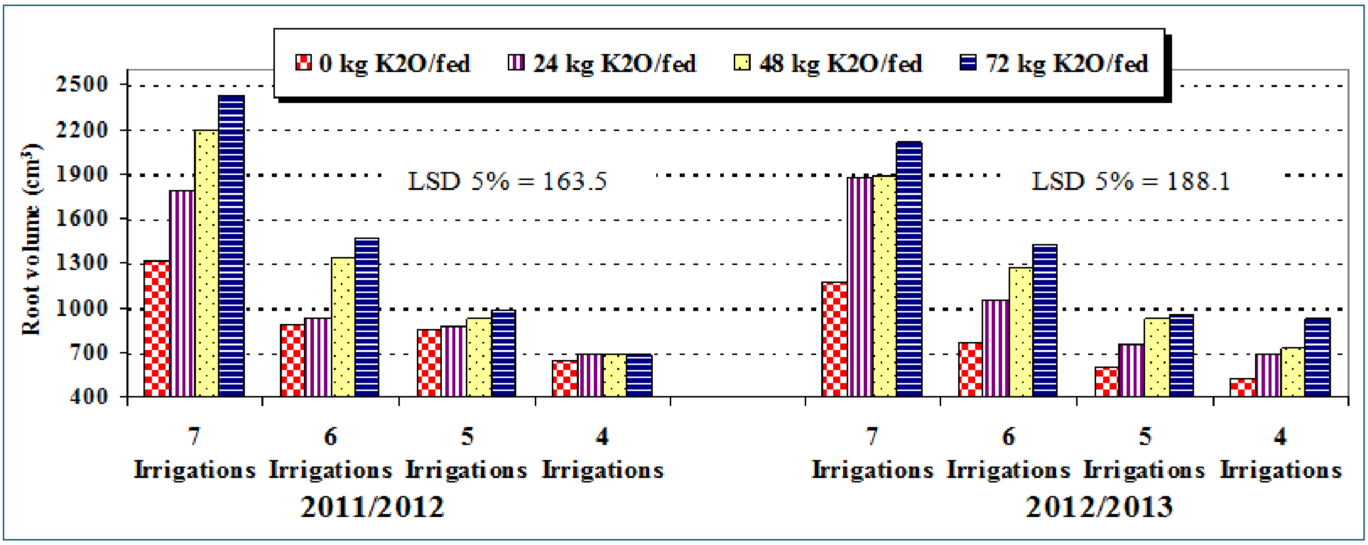

Fig. 5- Root volume (cm³) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

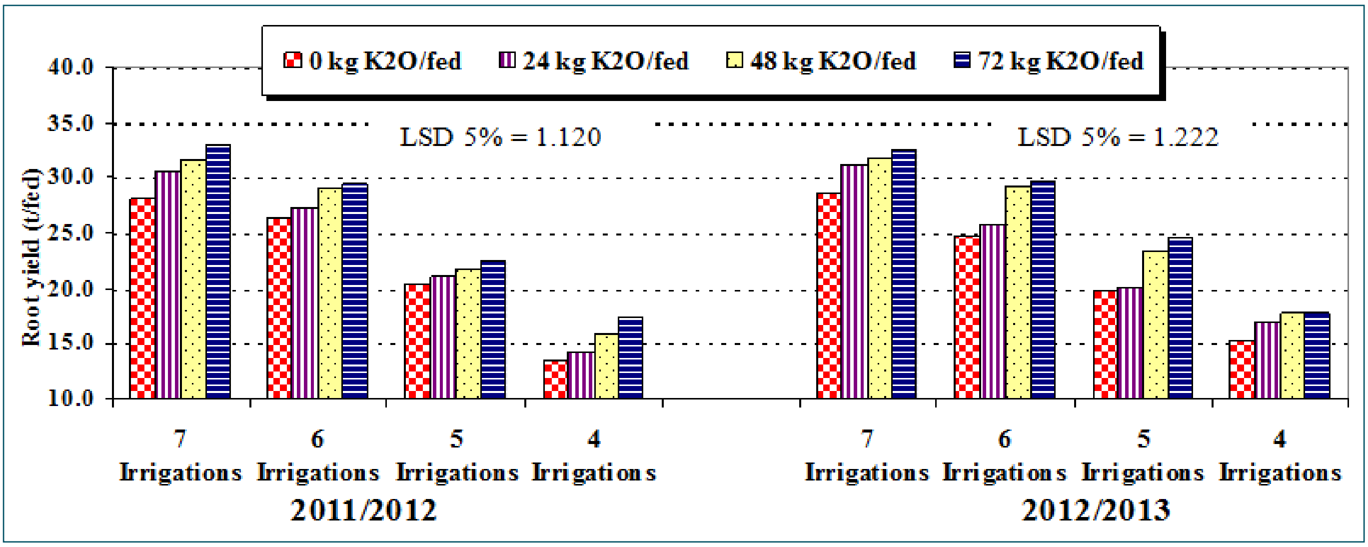

Fig. 6- Root yield (t/fed) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons

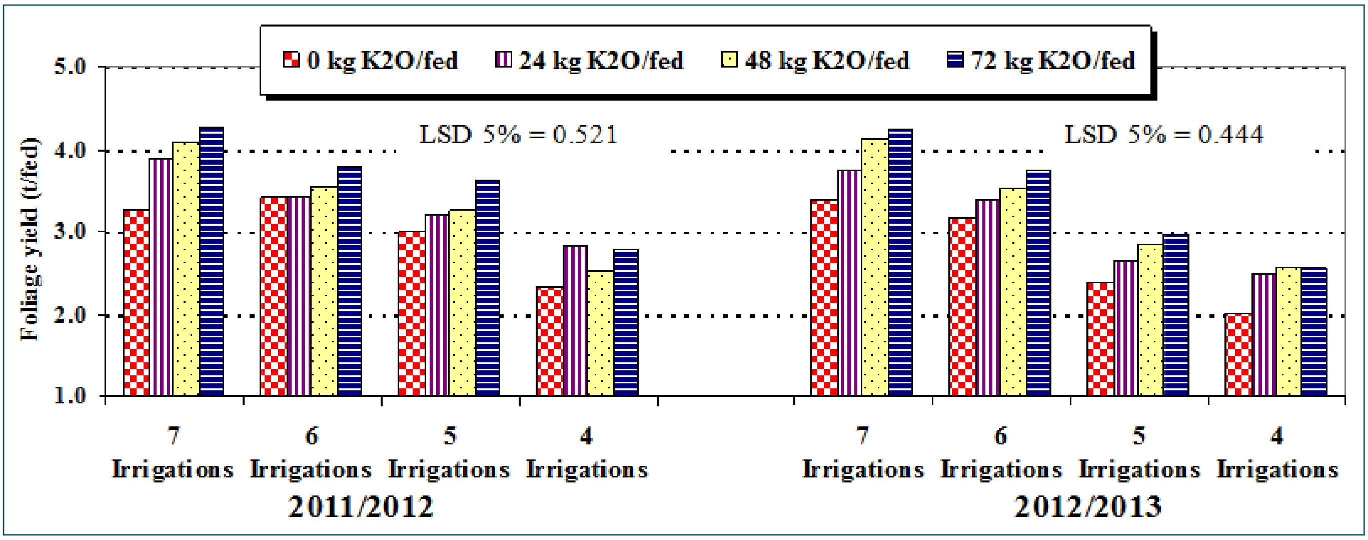

Fig. 7- Foliage yield (t/fed) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

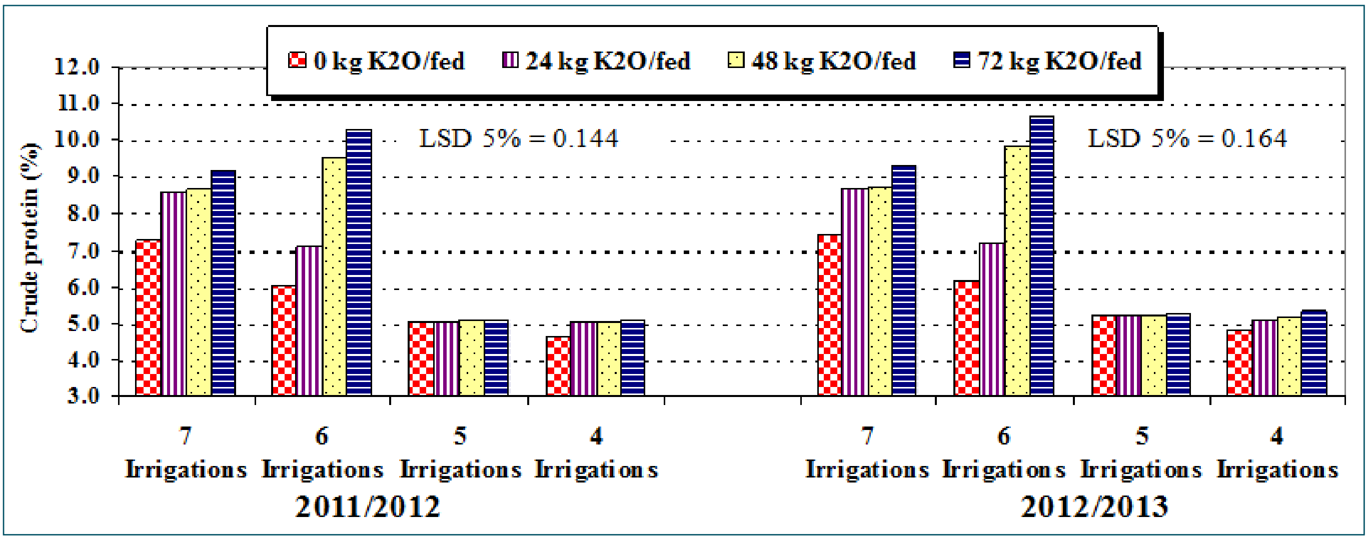

Fig. 8- Crude protein (%) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

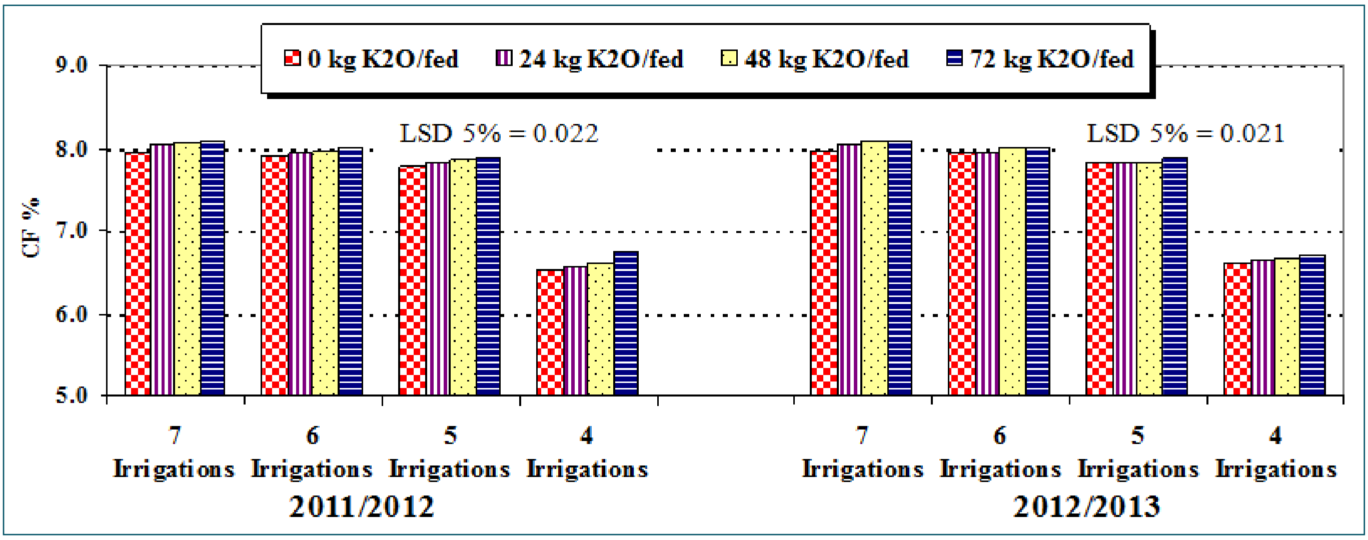

Fig. 9- Crude fiber percentage (CF%) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

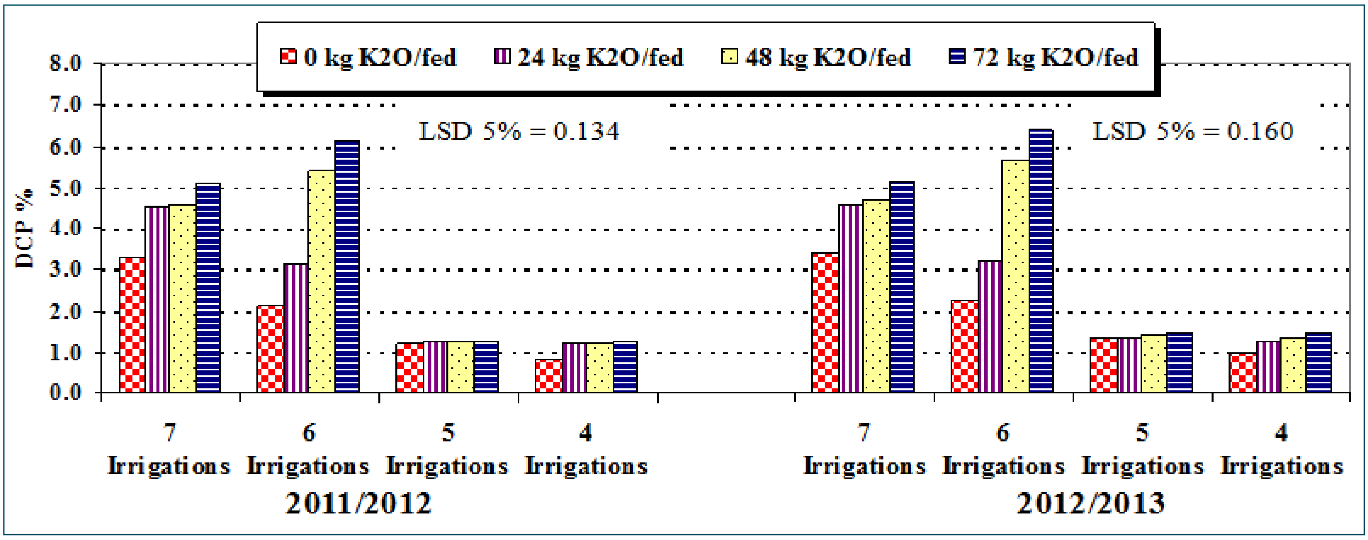

Fig. 10- Digestible crude protein percentage (DCP%) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

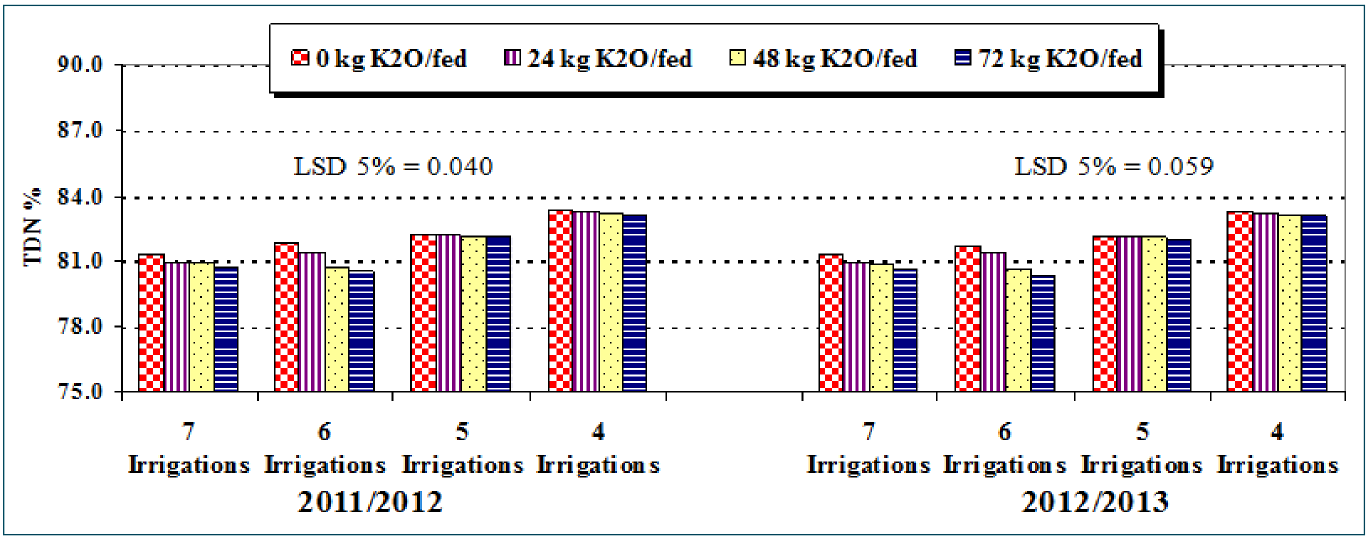

Fig. 11- Total digestible nutrients percentage (TDN%) as affected by the interaction between irrigation withholding treatments and potassium fertilizer levels during 2011/2012 and 2012/2013 seasons.

Forage Quality

Forage quality parameters *i.e.* total soluble solids (TSS), crude protein (CP), crude fiber (CF), potassium (K), digestible crude protein (DCP) and total digestible nutrients (TDN) percentages significantly affected due to irrigation withholding treatments in both seasons [Table-4]. The highest values of CP (8.44 and 8.53%), CF (8.05 and 8.06%), K (5.09 and 5.20%), and DCP (4.36 and 4.45%) were resulted from control treatment (giving fodder beet plants 7 irrigations) in the first and second seasons, respectively. However, giving fodder beet plants 6 irrigations ranked after control treatment without significant differences with concern CP, K and DCP percentages in both seasons. On the other hand, water stress treatments led to gradual increases in TSS and TDN percentages, where the highest percentages of TSS (14.50 and 15.25%) and TDN (83.23 and 83.14%) were produced from withholding last three irrigations (giving fodder beet plants 4 irrigations) in the first and second seasons, respectively. This effect of water stress during maturity stage and root formation may be due to the reduction in photosynthesis process and dry matter accumulation, which consequently decreasing crude protein and fiber percentage in forage. Similar results were detected by Ahmed [5] revealed that water stress reduced crude protein and potassium in roots.

Potassium fertilizer levels had a significant effect on crude protein (CP), crude fiber (CF), potassium (K), digestible crude protein (DCP) and total digestible nutrients (TDN) percentages in both seasons [Table-4]. The highest percentages of CP (7.43 and 7.63%), CF (7.66 and 7.67%), K (5.35 and 5.46%) and DCP (3.42 and 3.61%) were resulted from fertilizing fodder beet plants with 72 kg K_2O/fed in the first and second seasons, respectively. On the contrary, control treatment (without potassium fertilization) recorded the highest values of TDN (82.19 and 82.11%) in the first and second seasons, respectively. Concerning total soluble solids (TSS%), potassium fertilizer levels did not showed significant effect on TSS% in both seasons. These increases may be ascribed to the role of potassium on increasing photosynthetic activity which accounts much for high translocation of photoassimilates from leaves to the roots. Similar findings were stated by Ahmed [5] showed that potassium application increased crude protein and potassium in roots.

With respect to the effect of the interaction between irrigation treatments and potassium fertilizer levels, there was significant effect on crude protein (CP), crude fiber (CF), digestible crude protein (DCP) and total digestible nutrients (TDN) percentages in both seasons [Table-4]. The highest percentages of CP% [Fig-8] and DCP% [Fig-10] were produced from giving fodder beet plants 6 irrigations (withholding last irrigation) in addition fertilizing with 72 kg K_2O in both seasons. While, the highest percentages of CF% [Fig-9] were obtained as a result of giving fodder beet plants 7 irrigations (control treatment) in addition fertilizing with 72 kg K_2O in both seasons. Whereas, the highest percentages of TDN% [Fig-11] were resulted from giving fodder beet plants 4 irrigations (withholding last three irrigations) without potassium fertilization in the two growing seasons. Worth mentioning, withholding the last irrigation (giving fodder beet plants 6 irrigations) and fertilizing with 48 kg K_2O exceeded control treatment that most fodder beet farmers carried it (giving fodder beet plants 7 irrigations without potassium fertilization) with regard CP%, CF% and DCP% in both seasons. Thus, it can be save the last irrigation of fodder beet crop and compensated the incident reduction in forage yields and quality by using potassium fertilizer (48 kg K_2O).

Water Parameters

Water Consumptive Use (CU)

The effect of irrigation treatments and potassium fertilizers levels on averages water consumptive use for the two growing seasons is presented in [Table-5].

Table 5- Average water consumptive use (cm) as affected by irrigation withholding treatments and potassium fertilizer levels as averages during 2011/2012 and 2012/2013 seasons.

Potassium fertilizer levels:	Irrigation withholding treatments				
	7 irrigations	6 irrigations	5 irrigations	4 irrigations	Mean
0 kg K_2O/fed	47.28	40.5	35.6	29.1	38.12
24 kg K_2O/fed	48.9	42.5	36.6	30.2	39.55
48 kg K_2O/fed	50.18	43.6	37.5	31	40.57
72 kg K_2O/fed	51.5	44.4	38.7	32	41.65
Mean	49.465	42.75	37.1	30.575	39.79

It could be noticed that averages water consumptive use values were 49.46, 42.75, 37.10 and 30.58 cm for irrigation treatment, respectively. The water consumptive use values for potassium levels were 38.12, 39.55, 40.57 and 41.65 cm, respectively. Results presented in [Table-6] showed the averages of monthly CU values of the two growing seasons as affected by the tested variables. Results showed that water consumption increase as the growing season advances and reaches its peak during April 10.1 cm for Control (7 irrigations) and potassium fertilizers at the rate of 0 kg K_2O/fed treatment. Similar results were detected by Sayed, et al [21].

Crop Coefficient (Kc)

Results presented in [Table-7] indicated the monthly averages ET_a, ET_o values (mm/day) and crop coefficient (Kc) values for fodder beet crop at El-Serw Station Research. Kc values for growing seasons of fodder beet were developed using the calculated ET_o values by Class A Pan methods and measured ET_a values for irrigation treatment and potassium fertilizers level were used to calculate Kc values. Average Kc values for growing seasons of fodder beer crop at North Delta area is 0.88.

Table 6- Average water consumptive use (cm) as affected by irrigation withholding treatments and potassium fertilizer levels as averages during 2011/2012 and 2012/2013 seasons.

Month / K- levels (K_2O/fed)	7 irrigations				6 irrigations				5 irrigations				4 irrigations			
	0 kg	24 kg	48 kg	72 kg	0 kg	24 kg	48 kg	72 kg	0 kg	24 kg	48 kg	72 kg	0 kg	24 kg	48 kg	72 kg
November	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
December	3.9	4.1	4.3	4.4	3.4	3.4	3.8	3.9	3.1	3.3	3.5	3.6	2.3	2.5	2.7	2.9
January	6.4	6.5	6.7	6.8	5	5.4	5.6	5.8	4.2	4.3	4.4	4.6	3.1	3.3	3.4	3.6
February	7.9	7.9	8.1	8.3	6.2	6.5	6.8	6.9	5.1	5.3	5.4	5.6	4.3	4.4	4.6	4.7
March	9.2	9.5	9.7	9.9	8.1	8.3	8.5	8.6	7.2	7.3	7.6	7.8	5.6	5.8	5.8	5.9
April	9.3	8.6	9.7	10.1	8.3	8.5	8.6	8.7	7.4	7.5	7.7	7.9	6.1	6.3	6.5	6.7
May	8.2	8.9	9.3	9.6	7.1	7.8	7.9	8.1	6.2	6.9	6.5	6.8	5.3	5.5	5.6	5.8
Total	47.3	47.9	50.2	51.5	40.5	42.3	43.6	44.4	35.6	37	37.5	38.7	29.1	30.2	31	32

Table 7- Average of actual evapotranspiration (ETa), potential evapotranspiration (ETo) and crop coefficient (Kc) for fodder beet crop.

Month	ETa (mm/day)	ETo (mm/day) Pan evaporation	Kc Pan evaporation
November	0.9	1.5	0.6
December	1.4	1.7	0.8
January	2.2	1.9	1.15
February	2.9	2.7	1.07
March	3.2	3.3	0.96
April	3.3	3.8	0.86
May	3.8	5.4	0.7

Water Use Efficiency (WUE)

Water use efficiency as affected by irrigation treatments and potassium levels are presented in [Table-8]. Results indicated that WUE values was increased with increasing the number of irrigation and highest WUE values was 17.25 and 16.90 Kg/m^3water for withholding the last irrigation (6 irrigations) and the control treatment (7 irrigations) treatments, respectively.

It could be fulfilled that the control (7 irrigations) or withholding the last irrigation (6 irrigations) treatments and potassium fertilizers levels 72 kg K_2O/fed are suitable for fodder beet production at the North Delta area in Egypt.

Table 8- Water use efficiency values as affected by irrigation withholding treatments and potassium fertilizer levels.

	Irrigation withholding treatments				Potassium fertilizer levels			
	7 irrigations	6 irrigations	5 irrigations	4 irrigations	0 kg K_2O/fed	24 kg K_2O/fed	48 kg K_2O/fed	72 kg K_2O/fed
Total yield	16.9	17.25	15.83	14.53	15.94	16.2	16.54	16.78
Root yield	15.04	15.3	13.91	12.91	13.96	14.12	14.59	14.77

It could be noticed that WUE Values for potassium fertilizers level were equal values, but the highest potassium level 72 kg K_2O/fed recorded the highest approximately values 16.78Kg/m^3

Conclusion

From obtained results, the maximum values of forage yields and its components as well as forage quality were resulted from giving fodder beet plants 7 irrigations and fertilizing with 72 kg K_2O. The calculated seasonal average of fodder beet crop coefficient at North Delta was 0.97. In case of shortage of irrigation water at the end of plant life cycle or saving irrigation water, it could be recommended that withholding the last irrigation (giving fodder beet plants 6 irrigations) and compensated the reduction in forage yields through potassium fertilization (fertilizing with 48 kg K_2O instead of 72 kg K_2O to provide in terms of production costs. Where, the difference between them is not economically), in the same time overtook the treatment by most fodder beet farmers (giving plants 7 irrigations without potassium fertilization)under the environmental conditions of El-Serw district, Damietta Governorate.

Conflicts of Interest: None declared.

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