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Effects of Water Deficit on the Growth and Nutrient Uptake of Sugarcane (*Saccharum officinarum l.*) Plant and First Ratoon in Central Clay Plain of Sudan

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Abstract:
Field and nurse experiments were conducted during 2019/20 at Sugarcane Research Center Farm - Gunied (Sudan), to evaluate the effects of water deficit irrigation on the growth(root and shoot) and nutrient uptake of sugarcane plant and first ratoon, cultivar Co 6806. Nurse experiment used for root growth study. The experimental design was randomized complete block design (RCBD) replicated three times. The treatments comprised of two levels of water supply. The first was optimal irrigation (DT_0) with full Irrigation water applied when the available soil moisture in the root zone reached 60 % of the total available soil moisture (40 % depletion). The second treatment was applied when available soil moisture content (ASMC) reached 20 – 25 % in the root zone. These treatments were conducted at two growth periods; the first from day one to day fifty after germination of sugarcane and after establishment of first ratoon (DT_1). The second treatment for day fifty one to day hundred after germination and after establishment of ratoon (DT_2).

The results showed that water deficit has a negative effect on sugarcane shoot growth parameters, stem height, stem diameter, fresh and dry weight of shoot. Root growth parameters; root length and root dry weight at first growth period showed positive effect for plant cane with no significant difference. Also root shoot ratio (RSR) for height, fresh and dry weight and plant moisture percentage has positive effect with significant difference and clear increase. Moreover, nutrient uptake (NPK) was affected by water deficit on sugarcane crop cycle. Nitrogen uptake was decreased opposite to (P) and (K) with significant difference while at first ratoon nutrient uptake under irrigation deficit has increased (K) uptake and (NP) was decreased with significant difference. Therefore it can be concluded that irrigation deficit affects negatively the growth components of sugarcane crop.

Keywords: Sugarcane; irrigation; water deficit; growth period ; nutrient uptake

Introduction

Sugarcane (*Saccharum officinarum* L.) is a perennial crop belongs to the family Poaceae, an economically important cash crop in many countries around the world. Sugarcane estates of the Sudanese sugar company lie within the central clay plain of the Sudan. It is grown as an irrigation and strategic crop; however sugar industry in Sudan faced by a number of problems by which cane reduced in the last ten crushing seasons. The cane yield was 50.16 t ha^{-1}, which is far below the existing potential. The global harvest recently exceeding to175 million tons of sugar a year (FAO, 2016). That decrease in the yield potential is due to biotic and abiotic stresses. Among abiotic stresses, water deficit is a major stress that is increasing in Sudanese sugar schemes especially in Guneid sugar scheme (S.S.C. Annual Report, 2021). Due to its long growth cycle, sugarcane faces major environmental constrains that causes impact on its growth and development (Kumar *et al*., 2019). Many environmental factors affect the plant growth, yield and quality and most prominent is drought (Tawfik and El.Mouhamady, 2017 ; Misra, *et al*., 2020). Drought stress is the most important factor reducing ratooning ability and sugarcane production in the world. Reduction in cane yield has been estimated at up to 60 percent (Chumphu *et al*., 2018). Low yield of ratoon Drought effects the plant at every stages, some growth stages of crops are critical (Elkhalil *et al*., 2012; Tawfik and El.Mouhamady, 2017; Elkhalil *et al*., 2018). The water deficit is one of the main agriculture problems, even in regions with high annual rainfall but with uneven distribution throughout the crop cycle, which has been intensified in crops under the influence of adverse climatic conditions (Kolln *et al*., 2021). Although sugarcane can tolerate some moisture stress, it still has a high water requirement in the range of 1500 to 2500 mm per season in order to achieve yields close to the potential maximum. Therefore, to maintain optimum soil moisture throughout the growing period and to achieve close to maximum yields, both appropriate irrigation and drainage facilities are vital in sugarcane fields (Igbal *et al*., 2020). Misra *et al*., (2020) concluded that there are higher morphological losses in sugarcane in drought condition than in water logging conditions with respect to normal grown canes. Proper irrigation and nutrient management are therefore essential to achieving sugarcane yields close to the potential. Optimum soil moisture and nutrient availability have also been shown to increase the photosynthetic rate in sugarcane (Gunarathna e*t al*., 2018). Sugarcane plants require optimal rainfall during the vegetative phase to stimulate rapid growth, stalk elongation and inter node formation. However, during the period of maturity requires dry conditions with low rainfall to improve the quality of sugarcane juice and reduce the water content in plant tissues (Bhingardeve *et al*., 2017; Bhebhe *et al*., 2020). Root system and physiological traits of shoot may be inter-related, and the developmental stage of root strongly contributes to the total above-ground growth of plants (Gregory, 2006). Physiological traits related to photosynthesis such PSII photochemical efficiency (Fv/Fm), stomatal conductance, transpiration, SPAD index and water potential were identified as the traits promoting photosynthesis of sugarcane (Santos *et al*., 2015). However the information about water deficit effects on sugarcane establishment is rarely available; therefore the objective of this study is to evaluate the effects of irrigation water deficit on the growth and nutrient uptake of sugarcane crop cycles.

Materials and Methods

Two field experiments and one pot-culture experiment were conducted at the Sugarcane Research Center at Guneid farm, (14^o 47″ N, 33^o 19″ E and an altitude of 386 m above mean sea level), during 2019/20-2020\21 seasons. The objective was to evaluate the effects of irrigation deficit on the growth and nutrient uptake of sugarcane **(***Saccharum spp*.) plant and first ratoon, cultivar Co 6806. The soil was classified as Remaitab series which is Smectitic alluvium, clayey Vertisols with moderate chemical fertility and alkaline in reaction (Soil Survey Staff, 1999). The experimental design was Randomized Complete Block Design (RCBD). The field experimental unit was 112.5 m^2 (15m x 7.5m) consisted of five ridges. The study consisted of one experiment for plant cane and the other for the first ratoon were studied shoot growth with three replications. Root growth was studied with same fields' treatment by using pot experiment. The pot experiment unit with diameter of 10 cm and 30 cm depth was filled by one kilo-gram of clay soil same as field experiment soil. Sugarcane cultivar was planted on the first of November. Ratoon was established at December. Furrow irrigation was used for experiment and Parshal flume installed to measure the quantity of water entering the field plot. The treatments comprised of two levels of water supply. The first was optimal irrigation (DT_0) with full irrigation water applied when the available soil moisture in the root zone reached 60 % of the total available soil moisture (40 % depletion). The second treatment was applied when available soil moisture content (ASMC) reached 20 – 25 % in the root zone. These treatments were conducted at two growth periods; the first from day one to day fifty after germination of sugarcane and after establishment of first ratoon (DT_1). The second treatment for day fifty one to day hundred after germination and after establishment of ratoon (DT_2).

The reference evapotranspiration (ET_0) for Guneid area was computed using the FAO-Penman-Monteith approach (Smith *et al*., 1991) and CROPWAT software. Soil moisture content determination by gravimetric method (Farbrother, 1973) at 20 cm to 60 cm depth using an auger. Sampling was made at one day before irrigation and three day after irrigation throughout the growing season. Seasonal actual evapotranspiration (ET_a) and the irrigation required throughout the growing season were calculated according to the method described by Dooreenbos and kassam (1979). The seasonal amount of water requirement (CWR) for sugarcane crop was determined as function of the local climate, crop and soil data according to

Dooreenbos and Kassam (1979) as:

$$CWR= ET_0 \text{ X } kc,$$

where CWR is crop water requirement (mm day^{-1}), *ET*o is evapotranspiration of a reference plant under specified conditions, calculated by the class A pan evaporation method (mm day^{-1}), and *K*c is the crop water requirement coefficient for sugarcane.

From the central three ridges of field and from three pots. Growth parameters samples were taken from three fixed stools chosen from the inner rows per plot are plant height, stalk diameter and number of plants were determined. Moreover the fresh and dry weight of three plants on crop cycles was determined by chosen randomly from the three inner rows of each plot were cut to the base, weighted as fresh and separated into leaf sheath and stem and from each sample 200 g of fresh weight of sample was taken, air dried first and then oven dried at 80°C till constant weight was attained. The oven dry weight of each sample was determined and total dry matter production was computed. The root growth parameters were root length, root fresh weigh, root dry weight and root moisture of three plants. After that relation between root and shoot was calculated. Leaf analyses of sugarcane under water stress are essential for the determination of the nutrient up take. Moisture, phosphorus and potassium content in 3-6 leaf sheaths were determined as per the system evolved by Clements (1952) and adopted at Regional Agricultural Research Station, The oven dried sheath samples taking weights for moisture estimation were finely powered in a Willey Mill to pass through 2 mm sieve and the samples were used for estimation of phosphorus and potassium contents by Vanado-molybdate phosphoric acid yellow color method and Triacid extract- Flame photometer methods, respectively (Jackson, 1973). Nitrogen was estimated by Micro Kjeldahl method (Jackson, 1973**).** The collected data were analyzed using analysis of variance (ANOVA) technique to evaluate the differences among treatments. Means were separated using the least significant difference (LSD) at the 5% level of significance.

Results and Discussion

The effects of water deficit on shoot growth of sugarcane plant were shown on Tables 1 and 2. The results showed that water deficit had a negative effect on plant height of sugar cane, stem diameter, plant population, fresh and dry weight of the plants on the two crop cycles Table 3 and 4. Misra, *et al*.,(2020) implies that there are more morphological losses in canes exposed to drought condition than in canes exposed to water logging condition. This will contribute to more losses in production, productivity and yield of sugarcane grown under drought condition.

Plant height increased with increased of plant cane and ratoon age. Statistical analysis showed that the water deficit treatments have a significant effect on plant height. Plant height was reduced with water deficit application at the two growth periods compared with the optimum irrigation treatment for which maximum plant height was obtained. Water deficit during early stage of sugarcane reduced rates of stalk elongation and internodes length. Zhao *et al*., (2010) have found similar results that water stress reduced rates of plant elongation and node increment and there is a close relationship between plant height and stem diameter. Stalk and leaf prolongation rates are highly sensitive descriptors of plant water status and irrigation (Bamber, 2004). In a plant cane experiment, sugarcane grown under conditions of withholding irrigation during 150–210 day after planting had a lower LAI, NAR, CGR, and stalk elongation rate than that under 50% depletion of available soil moisture (Ramesh, 2000). Dehydration at the early stage of plant cane may be different with ratoon, because ratoon has a shorter drought duration. Analysis of variance showed that water deficit treatments significantly reduced stem diameter due the water stress restricted photosynthesis, elongation and lateral enlargement. These results agree with (Silva and Costa, 2000; Misra *et al*., 2020). Water deficit treatments had significantly decreased sugarcane plant population compared with optimum irrigation treatment which has produced intensive plant population. The reduction of plant population when water deficit applied to sugarcane crop cycles was probably due to reduction in number of tillers per plant (Misra *et al*., 2020). Zhao *et al*., (2010) who reported that water deficit reduced the number of tillers per plant. The effects of water deficit on fresh and dry weight of sugarcane plant and first ratoon was shown on Tables (1-4). The results showed that similar to the above finding, the fresh and dry weight was decreased when water deficit treatment applied with the differences statistically significant. Basnayka *et al*., (2012) who reported that water stress reduced the cane yield and dry weight of sugarcane

Table (1): Effects of water deficit on plant cane at the first growth period

Treat	H (cm)	F. wt (g)	D. wt (g)	M (%)	Th. (cm)	Pop (m^2)
DT_0	26.0 [a]	76.1 [a]	22.0 [a]	245.5[a]	1.33 [a]	30.0 [a]
DT_1	25.7 [b]	70.0 [b]	21.0 [b]	233.5[b]	1.22 [b]	29.0 [b]
Means	25.85	73.05	21.5	239.5	1.28	29.5
CV%	0.57	0.44	1.26	1.08	1.23	1.23
LSD (0.05)	0.30	0.74	0.62	5.9	0.036	0.74

H: height, F. wt: fresh weight, D. wt: Dry weight, M: moisture, Th: Thickness and Pop: Population. DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Table (2): Effect of water deficit on plant cane at the second growth period

Treatment	H (cm)	F. wt (g)	D. wt (g)	M (%)	Th.(cm)	Pop (m^2)
DT_0	35.0 [a]	94.0 [a]	26.0 [a]	261.5 [a]	1.53 [a]	49.0 [a]
DT_1	30.0 [b]	83.0 [b]	24.0 [b]	245.8 [b]	1.44 [b]	43.0 [b]
DT_2	28.0 [c]	78.0 [c]	23.0 [c]	239.2 [c]	1.37 [c]	36.0 [c]
Mean	31.0	85.0	24.4	248.84	1.44	42.73
CV%	0.19	0.12	0.70	0.93	0.83	2.08
LSD (0.05)	0.13	0.23	0.38	5.24	0.03	2.02

H: height, F. wt: fresh weight, D. wt: Dry weight, M: moisture, Th: Thickness and Pop: Population. DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Table (3): Effect of water deficit on sugarcane ratoon at the first growth period (DT_1).

H: height, F. wt: fresh weight, D. wt: Dry weight, M: moisture, Th: Thickness and Pop:

Treatment	H (cm)	F.wt (g)	D. wt (g)	M (%)	Th. (cm)	Pop (m^2)
DT_0	15.0 [a]	28.2 [a]	8.0 [a]	251.0 [a]	1.2 [a]	20.0 [a]
DT_1	11.0 [b]	27.2 [b]	7.7 [b]	200.0 [b]	1.0 [b]	15.0 [b]
Mean	13.0	27.7	7.85	225.5	1.1	17.5
CV%	0.30	0.45	1.07	1.37	3.37	1.21
LSD (0.05)	0.93	0.26	0.19	7.29	0.09	0.49

Population. DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Table (4): Effect of water deficit on sugarcane ratoon at the second growth period (DT_2).

Treatment	H (cm)	F.wt (g)	D.wt (g)	M (%)	Th (cm)	Pop (m^2)
DT_0	31.8^{a}	75.3^{a}	20.0^{a}	276.0^{a}	1.58^{a}	38.13^{a}
DT_1	22.0^{b}	64.97^{b}	18.1^{b}	257.3^{b}	1.27^{c}	31.10^{b}
DT_2	23.93^{b}	47.07^{c}	16.2^{c}	191.3^{c}	1.32^{a}	26.03^{c}
Mean	25.92	62.44	18.11	241.56	1.39	31.76
CV%	12.29	0.53	0.37	0.62	1.27	2.12
LSD (0.05)	7.22	0.74	0.15	3.42	0.04	1.52

H: height, F. wt: fresh weight, D. wt: Dry weight, M: moisture, Th: Thickness and Pop: Population. DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

The effects of water deficit on the root growth of sugarcane

Tables (5) and (6) show the effects of water deficit on sugarcane root growth at first and second growth periods. The results showed that water deficit had a negative effect on sugarcane root growth parameters viz; root length, fresh and dry weight on growth periods with significant effect. Root length and root dry weight at first growth period had positive effect with no significant difference. Jongrungklang *et al*., (2013) reported that the longer roots in response to drought are important for plant resistance to drought**,** therefore responses of root characteristics to water regime on sugarcane cultivar Co 6806 was significantly difference for major root growth parameters. So that stress conditions focus on traits, at the vegetative stage (Basu *et al*., 2016, Misra, *et al*., 2020). A decrease in both root dry weight and root length at second growth period opposite of first growth period with no significantly difference has been suggested for increasing the plant's ability to hold water and improve productivity under water deficit as Wasson *et al*., (2012) reported, and might be due the positive relationship between root length and soil water-limited conditions at first growth period shows the advantage of the increase in deep roots, for extracting water from deep soils over extended periods. The overall size of root systems is related to the uptake of water and nutrients from the soil and should be associated with drought resistance and growth performance under drought. Root system characteristic is an important consequence to soil drying and allows some roots to continue elongation under a water deficit to search more water. The distribution of the root schemes depended strongly on the soil moisture of the deeper soil layer (Derner *et al*., 2001). The smallest root distribution in depth directly affected total available water value reducing water range available to the plant and providing greater number of irrigations for maintaining proper water storage to plant (Bruno *et al*., 2020).

Table (5): Effect of water deficit on shoot and root of sugarcane at the first growth period.

Treat.	Shoot/plant				Root/plant			
	H (cm)	F. wt (g)	D. wt (g)	M (%)	L (cm)	F. wt (g)	D. wt (g)	M (%)
DT_0	25.0[a]	4.75[a]	1.50[a]	216.85[a]	14.75[a]	0.75[a]	0.35[a]	114.45[a]
DT_1	15.5[b]	1.80[b]	1.25[b]	44.00[b]	15.15[a]	0.50[b]	0.33[a]	51.50[b]
Mean	20.25	3.28	1.38	123.08	14.95	0.63	0.42	83.00
CV%	1.99	6.70	4.57	13.14	1.25	6.78	8.7	6.03
LSD	1.43	0.77	0.22	56.80	0.66	0.15	0.71	17.58
($P \leq 0.05$)								

H: height, F. wt: fresh weight, D. wt: Dry weight, M: moisture, Th: Thickness and Pop: Population. DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Table (6): Effect of water deficit on shoot and root sugarcane at ehe second growth period.

Treat.	Shoot/plant				Root/plant			
	H (cm)	F.wt (g)	D.wt (g)	M (%)	L (cm)	F.wt (g)	D.wt (g)	M (%)
DT_0	30.0 [a]	12.7[a]	5.5 [a]	131.9 [a]	25.00[a]	5.00[a]	3.50[a]	43.0[a]
DT_2	17.3 [b]	4.8 [b]	3.3 [b]	45.5 [b]	21.33[b]	2.17[b]	1.74[b]	25.0[b]
Mean	23.65	8.77	4.40	88.70	23.18	3.59	2.62	34.0
CV%	1.39	2.57	4.02	0.47	1.22	3.10	2.86	1.01
LSD								
($P \leq 0.05$)	1.16	0.79	0.62	1.45	0.99	0.39	0.26	1.21

H: height, F. wt: fresh weight, D. wt: Dry weight, M: moisture, Th: Thickness and Pop: Population. DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Root shoot ratio was significantly affected by water deficit Table (7) at plant height, fresh weight, dry weight and plant moisture percent with positive effect and clear increased in root shoot ratio as compared with optimum irrigation treatment. In common with other grasses, root: shoot ratios for sugarcane increased during early growth under deficit irrigation. Therefore, relative rates of shoot and root growth tend to compensate for above and below ground constraints in order to maintain a balance between the functional capacities of the roots and shoot. Thus, shoot caused root growth resulting in return of the root: shoot ratio to the value for control plants. The root system might be a more important sink than the top part of the plant under water deficit at the vegetative stage. In the course of the early growth stages of the water-limited condition, progressive accumulation of root dry matter was on the expense of shoot growth and the plants with adaptation to dry condition had higher root/shoot ratio. Once a decrease in the soil moisture content is detected, the roots must expand their distribution patterns and elongate into deeper soil layers for extracting and engaging a larger soil volume for water. As soil moisture at the soil surface and in the top soil profile was diminished under water deficit stress, the roots removed more water at the deeper profile. A deep root system is helpful for extracting water form substantial soil depths (Kavar *et al*., 2007). Under water-limit condition, plant invests in root growth higher than in shoot growth to take up more water. Under water-deficit condition, translocation of assimilates to roots was higher than to shoots (Azhiri-Sigari *et al*., 2000).The correlation between sugarcane grown under drought stress conditions and well-watered conditions were positive and significant ($P \leq 0.05$) for root-to-shoot ratio . However, sugarcane variety Co 6806 grown under drought conditions had similar trend for root-to-shoot ratio.

Table (7): Effects of water deficit on sugarcane growth root shoot ratio.

Treat.	Root/Shoot Ratio at 1^{st} growth period				Treat.	Root/Shoot Ratio at 2^{nd} growth period			
	L (cm)	F.wt (g)	D.wt (g)	M (%)		L (cm)	F.wt (g)	D.wt (g)	M (%)
DT_0	59.00^b	15.80^b	23.30^a	52.75^b	DT_0	83.30^b	39.37^b	52.72^b	33.0^b
DT_1	97.70^a	27.77^a	26.40^a	117.05^a	DT_2	123.30^a	45.20^a	63.64^a	55.0^a
Mean	78.35	21.79	24.85	84.90	Mean	103.30	42.27	58.18	43.99
CV%	1.95	3.12	4.36	9.12	CV%	1.74	0.011	4.2	0.96
LSD ($P \leq 0.05$)	5.38	2.39	3.8	27.20	LSD ($P \leq 0.05$)	6.32	0.16	8.57	1.49

H: height, F. wt: fresh weight, D. wt: Dry weight, M: moisture, Th: Thickness and Pop: Population. DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Water-deficit is main factor responsible for declining of sugarcane growth and yield due to unbalanced nutrition with (NPK) fertilization, the morphology of root structures is essential in accessing nutrients and soil water (Smith *et al*., 2005).Table (8) showed the effect of water deficit on sugarcane nutrient uptake (NPK) at plant cane; Nitrogen uptake was decrease opposite of (P and K) with significant , but at first ratoon nutrient uptake under deficit irrigation increase (K) uptake and decrease (P and N) with significant effect (Table 9). The effect of nitrogen was in enhancing P uptake due the availability of P increases and other micronutrients thus resulting in enhanced growth (Idrees *et al*., 2004), so that the decreasing in (P) was associated with the decreasing in (N) uptake. Therefore, deficit irrigation had negative effect on vegetative growth component due to decrease of N and P uptake. Thorburn *et al*. (2003) suggested that nutrient may similarly affect rooting patterns. So, availability of (N) affected by and on root activity, because of it is impacts on root distribution**.** Cane crops as well as ratoons both are highly exhaustive crop having higher demand for nitrogen. Decrease of nitrogen under deficit irrigation at two early growth periods may be due the shallow root system, decaying of old roots, sprouting of stubble buds and immobilization of nitrogen (Lal and Singh, 2008).Generally nutrient uptake was affect by water deficit on sugarcane crop cycle; increase in K uptake with decrease in (N and P) uptake but P increased at second growth period of sugarcane plant only. Reduction in(P) at two early growth periods of sugarcane ratoon under deficit irrigation may be due ratoon root activity and availability of (P) the concentration of (K) increased in both the sugarcane crop cycle under water deficit. (K) concentration began to increase and then decreases with the increasing of the crop age till it reached its less concentration values at second growth period in both plant cane and ratoon. The experimental results obtained from the study confirmed to that most of potassium is absorbed at the beginning of plant development, so that similar result found by (Medina *et al.* 2013). It is clear that the response of ratoon crop to potassium was more than in plant cane (Table 10) which agreed with the results of Kwong, (2001) who reported that the response to (K) in ratoon cane was considerably better than that for plant cane. Therefore water deficit significantly affected K+ uptake on sugarcane plant and ratoon. Sugarcane has greater stability and yield in response to N addition, with several studies confirming this positive effect of water on N uptake (Kolln et. al. 2016).

Table (8): Effect of water deficit on sugarcane nutrient uptake ((NPK) at growth

Treat.	Nutrient uptake ((NPK) at first growth period			Treat.	Nutrient uptake ((NPK) at second growth period		
	N (%)	P (ppm)	K(mg/kg)		N (%)	P (ppm)	K (mg/kg)
DT_0	0.52[a]	0.0071 [a]	14.25 [a]	DT_0	0.45 [a]	0.0041 [b]	13.63 [b]
DT_1	0.37[b]	0.0031 [b]	15.18 [a]	DT_2	0.38 [b]	0.0051 [a]	14.47 [a]
Mean	0.44	0.0051	14.72	Mean	0.42	0.0046	14.05
CV%	0.92	4.24	2.65	CV%	1.70	1.77	0.58
LSD (P $\leq$0.05)	0.014	0.00075	1.37	LSD (P $\leq$0.05)	0.024	0.0003	0.28

DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Table (9): Effect of water deficit on sugarcane first ratoon nutrient uptake (NPK) at establishment

Treat.	Nutrient uptake ((NPK) at first growth period			Treat.	Nutrient uptake ((NPK) at Second growth period		
	N (%)	P (ppm)	K(mg/kg)		N (%)	P (ppm)	K(mg/kg)
DT_0	0.95 [a]	0.0330 [a]	70.20 [b]	DT_0	0.79 [a]	0.027 [a]	69.10 [b]
DT_1	0.71 [b]	0.0123 [b]	72.63 [a]	DT_2	0.68 [b]	0.022 [a]	75.11 [a]
Mean	0.83	0.023	71.41	Mean	0.733	0.024	72.1
CV%	1.71	4.77	0.58	CV%	1.47	9.34	0.11
LSD ($P \leq 0.05$)	0.05	0.0038	1.46	LSD ($P \leq 0.05$)	0.038	0.0079	0.28

DT_0: Optimum irrigation, DT_1: Deficit irrigation. Means in the column followed by the same letter(s) are not significant differences according to LSD at 5% level.

Table (10): Effect of water deficit on sugarcane crop cycle nutrient up take ((N K) at growth

Treatments	Sugarcane **1st** growth period		Sugarcane **2nd** growth period	
	N (%)	K (mg/kg)	N (%)	K (mg/kg)
Pc	0.41 [b]	14.38 [b]	0.42 [b]	13.71 [b]
R_1	0.87 [a]	70.34 [a]	0.84 [a]	73.21 [a]
Mean	0.64	42.36	0.63	43.47
C.V %	13.25	4.15	10.27	4.90
LSD ($P \leq 0.05$)	0.092	1.92	0.07	2.32

Pc: plant cane R1: sugarcane first ratoon

Conclusions:

Water deficit had negative impact on growth components of sugarcane cultivar Co 6806 plant cane and ratoon. So that deficit irrigation must be avoided at early sugarcane growth periods. Negative impacts of expose sugarcane (variety Co 6806) under drought conditions were significant effect on growth of root, shoot, root-to-shoot ratio, and nutrient uptake by sugar plant and ratoon. Generally, water deficit reduced sugarcane fresh and dry weights per plant at early growth period and establishment of ratoon.

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أثار عجز المياه علي نمو وامتصاص العناصر الغذائية لنبات قصب السكرو الخلفة الاولي (*Saccharum officinarum l.*) في السهل الطيني الأوسط بالسودان.

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المستخلص

تم اجراء تجارب حقلية ومشتلية في موسمي 2019– 2020 في مزرعة ابحاث قصب السكر –الجنيد(السودان) لتقييم اثار الري الناجم عن نقص المياة علي النمو وامتصاص نبات السكر للمغذيات للنبات والخلفة الاولي الصنف Co 6806. التجربة المشتلية استخدمت لدراسة نمو الجذور.صممت التجربة بتصميم القطاعات الكاملة العشوائية ثلاث مرات. تتألف المعاملات من مستويين من امدادات المياه الاولي كان الري الامثل باستخدام مياه الري الكاملة عندما وصلت رطوبة التربة المتاحة في منطقة الجذر الي 60% من اجمالي رطوبة التربة المتاحة 40%. تم تطبيق المعاملة الثانية عندما وصل محتوي رطوبه التربة المتاح الي 20–25% في فترتي نمو, فترة النمو الاولي من (1–50 يوما) من الانبات(DT_1) وفترة النمو الثانية (51–100 يوم) من الانبات(DT_2) . والخلفة الاولي كانت من (51–100 يوم) من الانبات(DT_1).

اظهرت النتائج ان نقص المياه له تأثير سلبي علي نمو خلف ونبات قصب السكر لارتفاع الساق,قطر الساق,الوزن الرطب,والجاف ومعاملات نمو الجذر؛ طول الجذر والوزن الجاف للجذر .واظهر الوزن تأثيرا ايجابيا لقصب السكر مع عدم وجود فروقات معنوية ,كما ان نسبة المجموع الجذري للارتفاع والوزن الرطب له اثر ايجابي واضح ومعنوي .علاوة علي ذلك تأثر امتصاص المغذيات (النتروجين والفوسفور والبوتاسيم)بنقص المياة في دوره محصول قصب السكر . في ظل عجز الري زاد امتصاص البوتاسيم و انخفض امتصاص النتروجين والفوسفور مع وجود فرق معنوي.لذلك يمكن الاستنتاج ان عجز الري يؤثر سلبا علي مكونات نمو قصب السكر وامتصاصه للمغذيات.