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INFLUENCE OF PHOSPHATIC AND POTASSIC FERTILIZERS ON LEAF-N, P AND K OF TWO SUGARCANE VARIETIES GROWN ON THREE SOIL SERIES IN SUDAN

[44]

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ABSTRACT

A field trial was carried out for two consecutive seasons (1998 and 1999) at Sennar Sugarcane Company (latitude 13° 33'N and longitude 33° 37'E). The study was meant to examine the impact of phosphatic and potassium fertilization on plant cane and its ratoon contents of nitrogen, phosphorus and potassium. The treatments comprised of three levels of potassium (0, 72 and 144 kgK/ha applied as potassium chloride; three levels of phosphorus (0, 29 and 58 kgP/ha) applied as triple super phosphate (TSP); two sugar cane varieties (Co 6806 and Co 527) grown on three soil series (Hago, Nasr and Dinder). The treatments were arranged in a randomized complete block design and replicated thrice. Plant samples for analysis were taken at intervals of two months starting four months from planting up to ten months. The results showed that the mineral composition of cane plants was significantly affected by treatments. Leaf-N was high early in the season (3.23%) and started to decrease as the growing season proceeded (1.8%). The leaf-N values were low to high according to the standard concentrations. The leaf-N levels were higher in plant cane than those of the ratoon. Nasr soil series gave the highest values followed by Dinder and Hago series. Variety Co 6806 was better than Co 527. Leaf-P content was low according the standard levels ranging from 0.055 to 0.116%. Variety Co 6806 surpassed Co 527 in absorption of phosphorus. Leaf-P and leaf-K in ratoon were higher than those in the plant cane which indicated the residual effect of phosphorus and potassium fertilization. Leaf-K was in the insufficient range (1.33 – 2.04%). However, the data showed a significant rise in leaf-N, and leaf-K of plant cane and ratoon by 5-9% and 13-14%, respectively.

INTRODUCTION

Sugarcane production and industry expanded considerably in Sudan in the last four decades. However, the yield per unit area is well below the potential yield obtained abroad. This was thought to be due to the lack of nutrient supply mainly N, P, and K. Sugarcane is a heavy feeder crop that depletes the soil of these essential nutrients, therefore, adequate nutrient supply is essential.

Soils of Sudan are inherently deficient in nitrogen and are of very low phosphorus contents. Generally, the most important agricultural soils in Sudan suffer from nitrogen and phosphorus deficiency (**Gobara *et al* 1993**). Because of this, yield of most crops in Sudan is very low compared with that in many areas worldwide.

Fertilization of sugarcane at Northwest Sennar Scheme in Sudan was mostly limited to nitrogen, and small areas of the scheme received phosphorus, but very little was assigned to the response of

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cane to potassium fertilization (**El-Tilib *et al* 2004**). Therefore, this investigation was conducted to estimate the influence of soil type, sugarcane variety, phosphorus and potassium fertilization on the uptake of nitrogen, phosphorus and potassium by plant cane and its ratoon.

MATERIALS AND METHODS

A two-year field experiment was conducted in the seasons of 1998 and 1999 at Sennar Sugar Company in the Blue Nile State (latitude 13° 33' N and longitude 33° 37' E). The experimental site was disc ploughed, finely harrowed, leveled and ridged at 1.5 meter. The area was divided into plots 37.5 m^2 and 1.5 meter apart with 5 rows.

The experiment was carried out on three soil types using two sugarcane varieties and three levels of phosphatic and potassium fertilizers and their combinations. The soil types include: Dinder series classified as, very fine montmorillonite, isohyperthermic, Typic Chromusterts (Dinder clay); Hagu series classified as, fine kaolinitic, isohyperthermic, Ultic Haplustalfs (Hagu sandy clay) and Nasr series (Nasr sandy clay) occupying intermediate position between Dinder and Hagu series classified as fine, montmorillonite, iso-hyperthermic, Vertic Ustorthents (**El-Fadil, 1971**). Properties of the three soil types are presented in **Table (1).**

The cane varieties used were the most commonly grown in the scheme, namely, Co 6806 and Co527. Triple superphosphate fertilizer (TSP) was applied at three levels (0, 64.5 and 129 kg P_2O_5/ha) designated as P0, P1 and P2, respectively. The TSP was added in bands along the furrow at the time of planting. The rates of the added potassium were 0, 86 and 172 kg K_2O / ha designated as K0, K1 and K2, respectively. The recommended basal dressing of nitrogen was applied at the rate of 219 kgN/ha as urea. Both potassium and nitrogen fertilizers were mixed thoroughly and broadcasted by hand in continuous band in the furrow, buried and irrigated immediately two months after planting.

Table 1. Physical and chemical properties of examined soil series.

		Particle size distribution (%)				
Soil series	Depth (cm)	Coarse sand	Fine sand	Silt	Clay	Bulk Density
Dinder	0-30	17	6	25	52	1.66
	30-50	17	5	24	54	1.78
Nasr	0-30	29	6	17	48	1.89
	30-50	28	7	17	49	1.87
Hagu	0-30	41	8	14	37	1.88
	30-50	39	6	16	39	1.86

Soil series	Depth (cm)	pH (paste)	ECe (dS/m)	CEC ($mmol_c$/kg soil)	$CaCO_3$ (%)	O.C. (%)	TotalN (%)	Avial P (ug/g)
Dinder	0-30	8.00	0.40	640	0.80	0.91	0.05	2.2
	30-50	8.10	0.43	650	0.80	0.62	0.04	2.6
Nasr	0-30	7.44	0.34	540	2.2	0.94	0.04	1.8
	30-50	7.50	0.50	580	2.4	0.58	0.05	3.8
Hagu	0-30	7.05	0.56	460	1.4	0.94	0.04	3.6
	30-50	7.08	0.55	430	1.7	0.55	0.03	3.0

		Soluble cations and anions ($mmol_c$/l)					Exchangeable cations ($mmol_c$/kg soil)		
Soil series	Depth (cm)	Na	Ca	Mg	Cl	HCO_3	Exch.Na	Exch. K	Mobile K reserve
Dinder	0-30	3.20	1.00	0.20	2.40	3.00	0.92	0.58	1.28
	30-50	3.50	1.20	0.40	2.40	4.50	1.87	0.44	1.11
Nasr	0-30	1.25	2.10	1.00	2.80	5.00	0.34	0.66	1.38
	30-50	1.40	3.50	1.00	2.60	3.50	0.48	0.50	0.87
Hagu	0-30	1.30	4.00	2.00	2.70	4.70	0.30	0.54	1.65
	30-50	1.20	3.20	1.70	2.50	5.10	0.70	0.41	1.42

Four months after planting, the ridges were split to cover the base of the growing stools (hilling up). Weeding was performed through the use of Gezapax and Gezaprim herbicides prior to the second irrigation. Thereafter, hand weeding was practiced when necessary. Five stalks were selected randomly from the three inner rows in each plot and marked.

The parameters were measured at intervals of two months starting from the 4th month after planting and continued to the 10th month. The leaf sample was prepared from four most recently mature leaves (leaf number 3, 4, 5 and 6 from the top counting the rolled up spindle leaf as number 1) and pooled to constitute one sample. The leaves were cut into small pieces and dried in an oven at 70°C for 48 hours. The dried samples were ground separately by a grinder mill and kept for the chemical analysis.

The ratoon was considered as the second season of the crop. Therefore, after cane harvest, the ratoon was cut to ground level, plots were cleaned, irrigated and ridges were raised. The ratoon received similar doses of nitrogen, potassium and phosphorus fertilizers as the plant cane. Hand weeding was performed when necessary but no herbicides were added. All measurements, sampling and analysis were carried out following the field and laboratory methods employed for cane plant in the first year of the study.

Chemical Analysis

Micro-Kjeldahl method was used for plant nitrogen determinations. Leaf phosphorus was detected using vanado-molybdate colorimetric method described by **AOAC (1970)**. Leaf-calcium, magnesium, sodium and potassium were determined using atomic absorption spectrophotometer, model 2380, Perkin Elmer. The treatments were arranged in a randomized complete block design and replicated thrice. Statistical analysis was performed and the means were separated using Duncan Multiple Range Test.

RESULTS AND DISCUSSIONS

Nitrogen

The uptake of nitrogen by cane early in the season increased significantly as a result of phosphorus application but later it became low. According to **Wolf *et al* (1985)**, the level of leaf nitrogen was sufficient up to the 6th month but, thereafter, it was reduced to the lower limit. A positive correlation between phosphorus and nitrogen concentrations of plant shoot was established **(Bar Yousef *et al* 1995 and Azcon, *et al* 1996)**. The results showed that the influence of potassium fertilizer on nitrogen uptake by plant cane was generally negative during the first 8 months after planting **(Table 2)**. This could be explained by the possible antagonism between nitrogen and potassium because potassium modifies ammonium (NH^{4+}) ion fixation in soils to restrict nitrogen availability. This was attributed to the contraction of clay lattices as a result of potassium application, hence blocking the release of the fixed ammonium **(Somorowska, 1987 and Daliparthy, *et al* 1994)**. On the other hand, application of potassium fertilizer to ratoon increased the nitrogen uptake throughout the growth of the plant cane **(Table 3)**. This was almost due to the efficient root system of the ratoon which enabled the search of nutrients in larger soil volume **(Yavda and Singh, 1992)**. However, the levels of leaf nitrogen, phosphorous and potassium were relatively high early in the season and tended to decline towards the end of the season **(Mengel & Kirkby 1978)**. It was concluded that plant cane attained its maximum requirement of nutrients at the age of 6 months when full development of leaves occurred and the requirement of plant for these nutrients decreases thereafter.

Phosphorous

Leaf phosphorous content in plant cane showed an insignificant increase in response to phosphorous fertilization **(Table 4)**. These insignificant responses to the added phosphorous could be attributed to the ability of most soils to immobilize the added phosphorous **(Barvalle, *et al* 1995 and Tsadilas, *et al* 1996)**. The level of leaf phosphorous in ratoon was significantly increased early in the season when fertilizer phosphorous was added **(Table 5)**. However, the level of phosphorus in both plant cane and ratoon is in the lower range **(Wolf, *et al* 1985)**. This may be due to the phosphorus retention by hydrous iron oxides or adsorption by clay particles **(Elmahi and Mustafa, 1980)**. It is worth mentioning that the ratoon leaf phosphorous content was higher than that of plant cane. This may suggest that in the ratoon there would be less fixation of the added phosphorous and the residual effect of phosphorous applied in the first season will be in favour of the ratoon **(Korndorfer and Alcarde, 1992)**. Addition of potassium fertilizer did not affect the level of leaf phosphorous in plant cane

Table 2. Mean leaf nitrogen content (%) of plant cane as affected by treatments

Variety	Fertilizer rate		4 months from planting				6 months from planting				8 months from planting				10 months from planting			
			Soil series			MVE	Soil series			MVE	Soil series			MVE	Soil series			MVE
	K	P	Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu	
		P0	2.45	3.10	1.52		2.40	3.20	2.00		2.13	2.39	1.51		1.50	1.95	1.60	
	K0	P1	2.40	2.80	1.89		2.10	3.41	2.22		2.02	2.46	1.57		1.41	1.95	1.56	
		P2	2.44	3.40	1.71		2.33	3.50	1.90		2.17	2.20	1.36		1.45	1.79	1.38	
		P0	2.50	2.98	1.60		2.22	3.70	1.95		2.22	2.18	1.49		1.33	1.96	1.60	
Co 6806	K1	P1	2.62	2.67	1.65	2.39b	2.72	3.80	1.91	2.54a	2.10	2.30	1.45	1.93a	1.38	1.93	1.52	1.61b
		P2	2.49	3.10	1.68		2.48	3.06	2.07		2.03	1.81	1.49		1.44	1.88	1.54	
		P0	2.50	2.76	1.59		2.23	3.42	2.08		2.20	1.78	1.48		1.45	1.84	1.60	
	K2	P1	2.72	3.05	1.65		2.23	3.13	1.95		2.18	2.19	1.36		1.30	1.92	1.58	
		P2	2.54	2.88	1.80		2.25	3.24	2.16		2.00	1.74	1.39		1.32	1.75	1.55	
		P0	2.70	3.48	1.56		2.10	2.60	1.83		2.00	2.03	1.17		1.35	1.82	1.50	
	K0	P1	2.61	3.95	1.60		2.19	3.00	2.00		1.96	2.13	1.29		1.30	1.67	1.63	
		P2	2.53	3.43	1.67		2.10	3.17	1.80		2.00	2.02	1.30		1.30	1.69	1.31	
		P0	2.58	3.20	1.50		2.10	3.05	1.89		1.80	2.00	1.42		1.46	1.60	1.60	
Co 527	K1	P1	2.71	3.98	1.63	2.56a	2.13	3.38	1.99	2.36b	2.02	1.98	1.40	1.77b	1.40	1.76	1.76	1.76a
		P2	2.80	2.90	1.42		2.12	2.53	2.00		1.95	2.09	1.33		1.40	1.82	1.66	
		P0	2.56	3.80	1.52		2.20	3.56	1.94		1.80	2.10	1.39		1.30	1.71	1.59	
	K2	P1	2.69	3.43	1.56		2.16	3.45	1.86		2.08	2.06	1.31		1.45	1.70	1.70	
		P2	2.68	3.19	1.50		1.96	2.55	2.12		1.90	2.00	1.36		1.45	1.85	1.69	
MSE			2.58b	3.23a	1.61c		2.22b	3.21a	1.98c		2.04b	2.08a	1.39c		1.34c	1.81a	1.58b	

4 months			6 months			8 months			10 months		
Main K effect			Main K effect			Main K effect			Main K effect		
K0	K1	K2	K0	K1	K2	K0	K1	K2	K0	K1	K2
2.51a	2.45b	2.47b	2.44b	2.51a	2.42b	1.87a	1.84b	1.81c	1.56b	1.61a	1.60a
Main P effect			Main P effect			Main P effect			Main P effect		
P0	P1	P2	P0	P1	P2	P0	P1	P2	P0	P1	P2
2.44b	2.53a	2.45b	2.42b	2.54a	2.41b	1.84b	1.88a	1.78c	1.60a	1.61a	1.57b
Variety SE = ±0.01			Variety SE = ±0.009			Variety SE = ±0.009			Variety SE = ±0.004		
Soil, K and P SE = ±0.014			Soil, K and P SE = ±0.011			Soil, K and P SE = ±0.011			Soil, K and P SE = ±0.005		
CV = 4.04%			CV = 3.13%			CV = 4.32%			CV = 2.08%		

Symbols used in this table and the following tables are explained as follows: P0 = No phosphorus; P1 = 64.5 kg P_2O_5/ha; P2 = 129 kg P_2O_5/ha; K0 = No potassium, K1 = 86 kg K_2O_5/ha; K2 = 172 kg K_2O_5/ha.; MVE = Main variety effect; MSE = Main soil effect; CV = Coefficient of variation.

Means followed by the same letter do not differ significantly using Duncan's Multiple Range Test at 1 and 5%

Table 3. Mean leaf nitrogen content (%) of ratoon as affected by treatments

Variety	Fertilizer rate		4 months from planting				6 months from planting				8 months from planting				10 months from planting			
			Soil series			MVE	Soil series			MVE	Soil series			MVE	Soil series			MVE
	K	P	Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu	
		P0	1.60	1.63	1.79		1.97	1.78	1.54		1.49	1.69	1.47		1.54	1.49	1.65	
	K0	P1	1.87	1.79	1.99		2.15	1.86	1.83		1.72	1.98	1.55		1.83	1.64	1.89	
		P2	1.99	1.87	2.04		2.20	1.93	1.85		1.68	2.02	1.49		1.77	1.67	1.88	
		P0	1.66	2.01	2.02		2.22	2.10	1.86		1.74	1.83	1.63		1.80	1.43	1.93	
Co 6806	K1	P1	2.10	1.72	2.18	1.92a	2.40	2.40	2.04	1.98a	1.91	1.87	1.54	1.69a	1.94	1.54	2.00	1.75a
		P2	2.10	1.82	1.92		2.09	1.85	1.84		1.68	1.92	1.52		1.80	1.52	1.82	
		P0	1.76	2.00	2.11		2.16	2.08	1.87		1.75	1.86	1.52		1.88	1.60	1.89	
	K2	P1	2.00	1.80	1.79		2.05	1.84	1.74		1.70	1.81	1.43		1.80	1.62	1.74	
		P2	1.70	1.66	1.80		2.16	1.92	1.70		1.70	1.78	1.53		1.75	1.61	1.85	
		P0	1.52	1.77	1.52		2.00	1.72	1.59		1.50	1.57	1.35		1.58	1.48	1.52	
	K0	P1	1.90	1.98	1.99		2.24	1.89	1.78		1.60	1.77	1.62		1.62	1.80	1.65	
		P2	1.96	1.89	2.00		2.21	1.85	1.73		1.65	1.67	1.45		1.68	1.70	1.65	
		P0	1.72	1.95	1.75		2.12	1.93	1.77		1.62	1.86	1.52		1.73	1.76	1.75	
Co 527	K1	P1	2.05	2.15	2.10	1.86b	2.31	2.19	1.93	1.95b	1.65	1.93	1.76	1.65b	1.79	1.81	1.78	1.71b
		P2	2.05	1.90	1.98		2.30	1.91	1.73		1.74	1.82	1.59		1.76	1.61	1.83	
		P0	1.74	1.99	1.91		2.33	1.93	1.80		1.73	1.84	1.51		1.88	1.87	1.65	
	K2	P1	2.00	2.00	2.01		2.16	1.97	1.77		1.56	1.72	1.43		1.68	1.77	1.82	
		P2	1.79	1.91	1.93		2.00	1.91	1.71		1.70	1.73	1.53		1.78	1.77	1.85	
MSE			1.86b	1.88b	1.94a		2.17a	1.95b	1.78c		1.67b	1.82a	1.52c		1.76a	1.65b	1.79a	
			Main K effect				Main K effect				Main K effect				Main K effect			
			K0	K1	K2		K0	K1	K2		K0	K1	K2		K0	K1	K2	
			1.84c	1.95a	1.88b		1.90c	2.06a	1.95b		1.63c	1.73a	1.66c		1.67b	1.76a	1.77a	
			Main P effect				Main P effect				Main P effect				Main P effect			
			P0	P1	P2		P0	P1	P2		P0	P1	P2		P0	P1	P2	
			1.80c	1.97a	1.91b		1.93b	2.03a	1.94b		1.64b	1.70a	1.68a		1.69b	1.76a	1.74a	
			Variety SE = ±0.013				Variety SE = ±0.009				Variety SE = ±0.009				Variety SE = ±0.011			
			Soil, K and P SE = ±0.015				Soil, K and P SE = ±0.011				Soil, K and P SE = ±0.011				Soil, K and P SE = ±0.013			
			CV = 5.96%				CV = 3.91%				CV = 4.74%				CV = 5.61%			

Symbols as defined in Table (2).

Table 4. Mean leaf phosphorus content (%) of plant cane as affected by treatments

Variety	Fertilizer rate		4 months from planting				6 months from planting				8 months from planting				10 months from planting			
			Soil series			MVE	Soil series			MVE	Soil series			MVE	Soil series			MVE
	K	P	Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu	
Co 6806	K0	P0	0.057	0.099	0.094		0.124	0.120	0.083		0.081	0.110	0.081		0.083	0.089	0.073	
		P1	0.055	0.091	0.116		0.108	0.128	0.092		0.076	0.113	0.084		0.076	0.090	0.070	
		P2	0.056	0.105	0.079		0.120	0.129	0.075		0.082	0.108	0.070		0.083	0.080	0.064	
	K1	P0	0.056	0.091	0.096		0.113	0.136	0.080		0.082	0.110	0.079		0.075	0.092	0.072	
		P1	0.058	0.083	0.090	0.080a	0.137	0.141	0.077	0.109a	0.075	0.109	0.076	0.087a	0.080	0.086	0.069	0.079a
		P2	0.058	0.090	0.091		0.136	0.111	0.083		0.078	0.103	0.078		0.080	0.088	0.071	
	K2	P0	0.057	0.083	0.088		0.114	0.125	0.085		0.082	0.100	0.078		0.080	0.085	0.073	
		P1	0.061	0.095	0.089		0.113	0.117	0.078		0.080	0.103	0.071		0.076	0.086	0.069	
		P2	0.052	0.083	0.097		0.122	0.116	0.086		0.070	0.105	0.072		0.076	0.083	0.071	
Co 527	K0	P0	0.055	0.097	0.066		0.111	0.091	0.064		0.066	0.090	0.060		0.076	0.093	0.060	
		P1	0.052	0.108	0.072		0.091	0.103	0.070		0.064	0.094	0.066		0.073	0.085	0.065	
		P2	0.050	0.088	0.091		0.083	0.094	0.074		0.065	0.086	0.063		0.074	0.084	0.050	
	K1	P0	0.052	0.083	0.077		0.124	0.091	0.071		0.059	0.086	0.070		0.083	0.080	0.062	
		P1	0.052	0.101	0.083	0.077b	0.134	0.097	0.071	0.093b	0.063	0.083	0.070	0.073b	0.083	0.087	0.070	0.076b
		P2	0.069	0.086	0.095		0.124	0.091	0.072		0.065	0.100	0.069		0.076	0.094	0.069	
	K2	P0	0.050	0.099	0.095		0.113	0.110	0.070		0.058	0.091	0.069		0.073	0.086	0.063	
		P1	0.052	0.091	0.083		0.102	0.108	0.078		0.065	0.090	0.064		0.083	0.086	0.065	
		P2	0.052	0.091	0.099		0.113	0.091	0.076		0.060	0.090	0.070		0.088	0.095	0.068	
MSE			0.055c	0.092a	0.089b		0.116a	0.110b	0.077c		0.071b	0.098a	0.072b		0.079b	0.087a	0.067c	
			Main K effect				Main K effect				Main K effect				Main K effect			
			K0	K1	K2		K0	K1	K2		K0	K1	K2		K0	K1	K2	
			0.080a	0.078a	0.079a		0.098b	0.105a	0.101b		0.081a	0.081a	0.079a		0.076a	0.077a	0.078a	
			Main P effect				Main P effect				Main P effect				Main P effect			
			P0	P1	P2		P0	P1	P2		P0	P1	P2		P0	P1	P2	
			0.078a	0.080a	0.080a		0.101a	0.103a	0.100a		0.081a	0.080a	0.080a		0.078a	0.078a	0.077a	
			Variety SE = ±0.0009				Variety SE = ±0.001				Variety SE = ±0.001				Variety SE = ±0.0009			
			Soil, K and P SE = ±0.0011				Soil, K and P SE = ±0.0012				Soil, K and P SE = ±0.0012				Soil, K and P SE = ±0.0011			
			CV = 10.53%				CV = 9.42%				CV = 11.50%				CV = 11.01%			

Symbols as defined in Table (2).

Table 5. Mean leaf phosphorus content (%) of ratoon as affected by treatments

Variety	Fertilizer rate K	Fertilizer rate P	4 months from planting: Soil series Dinder	Nasr	Hagu	MVE	6 months from planting: Soil series Dinder	Nasr	Hagu	MVE	8 months from planting: Soil series Dinder	Nasr	Hagu	MVE	10 months from planting: Soil series Dinder	Nasr	Hagu	MVE
	K0	P0	0.078	0.100	0.095		0.106	0.110	0.096		0.097	0.090	0.084		0.067	0.085	0.070	
		P1	0.096	0.111	0.105		0.115	0.115	0.114		0.099	0.106	0.088		0.078	0.094	0.080	
		P2	0.104	0.114	0.105		0.120	0.118	0.112		0.099	0.107	0.081		0.078	0.094	0.075	
	K1	P0	0.085	0.121	0.106		0.115	0.120	0.115		0.096	0.096	0.092		0.075	0.080	0.080	
Co 6806		P1	0.106	0.096	0.114	0.101a	0.126	0.133	0.126	0.113a	0.103	0.097	0.086	0.094a	0.079	0.086	0.082	0.092a
		P2	0.108	0.102	0.100		0.112	0.105	0.113		0.097	0.100	0.084		0.078	0.085	0.074	
	K2	P0	0.089	0.121	0.111		0.114	0.120	0.116		0.095	0.098	0.086		0.078	0.090	0.079	
		P1	0.101	0.110	0.093		0.108	0.113	0.106		0.092	0.096	0.079		0.074	0.092	0.070	
		P2	0.083	0.091	0.093		0.110	0.105	0.103		0.090	0.092	0.084		0.071	0.089	0.074	
	K0	P0	0.073	0.099	0.080		0.092	0.104	0.101		0.085	0.090	0.080		0.076	0.082	0.071	
		P1	0.090	0.109	0.104		0.100	0.111	0.113		0.088	0.099	0.095		0.076	0.095	0.077	
		P2	0.091	0.102	0.100		0.098	0.107	0.104		0.090	0.092	0.083		0.078	0.086	0.074	
	K1	P0	0.082	0.108	0.091		0.096	0.114	0.112		0.091	0.105	0.089		0.083	0.097	0.080	
Co 527		P1	0.090	0.118	0.109	0.098b	0.100	0.128	0.122	0.108b	0.079	0.107	0.103	0.091b	0.075	0.092	0.081	0.080a
		P2	0.099	0.106	0.105		0.111	0.115	0.112		0.099	0.103	0.095		0.091	0.089	0.087	
	K2	P0	0.080	0.105	0.099		0.103	0.111	0.109		0.093	0.101	0.087		0.087	0.094	0.075	
		P1	0.088	0.109	0.101		0.094	0.115	0.107		0.075	0.095	0.082		0.072	0.090	0.082	
		P2	0.080	0.105	0.102		0.088	0.112	0.109		0.086	0.096	0.091		0.080	0.091	0.087	
MSE			0.090c	0.107a	0.101b		0.106c	0.114a	0.111b		0.091b	0.098a	0.087c		0.091a	0.090a	0.077a	

	4 months from planting			6 months from planting			8 months from planting			10 months from planting		
Main K effect	K0	K1	K2	K0	K1	K2	K0	K1	K2	K0	K1	K2
	0.098b	0.103a	0.098b	0.108b	0.115a	0.108b	0.091b	0.096a	0.090b	0.080a	0.097a	0.082a
Main P effect	P0	P1	P2	P0	P1	P2	P0	P1	P2	P0	P1	P2
	0.096c	0.103a	0.099b	0.109b	0.114a	0.109b	0.091a	0.093a	0.093a	0.080a	0.096a	0.082a
Variety SE	±0.0008			±0.0009			±0.0007			±0.007		
Soil, K and P SE	±0.001			±0.0011			±0.0009			±0.008		
CV	7.53%			7.16%			7.55%			6.99%		

Symbols as defined in Table (2).

Table 6. Mean leaf potassium content (%) of plant cane as affected by treatments

Variety	Fertilizer rate		4 months from planting				6 months from planting				8 months from planting				10 months from planting			
			Soil series			MVE	Soil series			MVE	Soil series			MVE	Soil series			MVE
	K	P	Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu	
Co 6806	K0	P0	1.30	1.40	1.40	1.54a	1.95	1.88	1.76	2.01a	1.92	2.17	1.69	1.98a	1.57	1.68	1.54	1.69a
		P1	1.29	1.25	1.78		1.74	1.99	2.00		1.87	2.21	1.80		1.60	1.66	1.56	
		P2	1.30	1.70	2.00		1.92	2.10	2.03		1.98	2.25	1.75		1.59	1.62	1.70	
	K1	P0	1.35	1.71	1.52		1.88	2.23	1.78		2.09	2.30	1.73		1.61	1.90	1.63	
		P1	1.46	1.28	1.71		2.35	2.27	1.83		2.03	2.20	1.74		1.78	1.70	1.65	
		P2	1.31	1.81	1.78		2.12	2.12	2.05		1.81	2.26	1.81		1.48	1.91	1.71	
	K2	P0	1.35	1.60	1.55		1.87	2.23	1.95		2.04	2.15	1.76		1.70	1.82	1.66	
		P1	1.48	1.45	1.80		1.92	1.85	1.97		2.07	2.06	1.67		1.64	1.66	1.80	
		P2	1.43	1.69	2.02		1.96	2.41	2.24		1.95	2.33	1.74		1.79	1.82	1.86	
Co 527	K0	P0	1.26	1.40	1.48	1.45b	1.52	1.78	1.55	1.79b	1.62	1.77	1.33	1.67b	1.52	1.83	1.35	1.64b
		P1	1.25	1.60	1.55		1.62	2.04	1.70		1.60	1.88	1.49		1.53	1.70	1.47	
		P2	1.27	1.53	1.80		1.58	1.96	1.98		1.65	1.88	1.66		1.56	1.83	1.30	
	K1	P0	1.23	1.42	1.56		1.53	1.89	1.75		1.46	1.83	1.71		1.70	1.67	1.50	
		P1	1.40	1.83	1.64		1.89	2.10	1.74		1.73	1.92	1.64		1.92	1.93	1.59	
		P2	1.30	1.11	1.30		1.47	1.72	1.66		1.56	1.77	1.48		1.45	1.80	1.45	
	K2	P0	1.29	1.67	1.55		1.70	2.21	1.72		1.49	1.90	1.64		1.57	1.77	1.45	
		P1	1.38	1.50	1.65		1.87	2.15	2.01		1.77	1.83	1.59		1.90	1.75	1.66	
		P2	1.36	1.25	1.49		1.67	1.75	1.77		1.60	1.73	1.54		1.80	1.85	1.50	
MSE			1.33c	1.51b	1.64a		1.81c	[illegible]	1.86b		1.79b	2.02a	1.65c		1.65b	1.77a	1.58c	

4 months from planting	6 months from planting	8 months from planting	10 months from planting
Main K effect	Main K effect	Main K effect	Main K effect
K0 1.48b, K1 1.48b, K2 1.53a	K0 1.84c, K1 1.91b, K2 1.96a	K0 1.80b, K1 1.84a, K2 1.82a	K0 1.59c, K1 1.68b, K2 1.72a
Main P effect	Main P effect	Main P effect	Main P effect
P0 1.45b, P1 1.52a, P2 1.52a	P0 1.84b, P1 1.95a, P2 1.92a	P0 1.80b, P1 1.84a, P2 1.82a	P0 1.63b, P1 1.69a, P2 1.67a
Variety SE = ±0.01	Variety SE = ±0.011	Variety SE = ±0.009	Variety SE = ±0.01
Soil. K and P SE = ±0.012	Soil. K and P SE = ±0.014	Soil. K and P SE = ±0.011	Soil. K and P SE = ±0.012
CV = 5.40%	CV = 5.36%	CV = 4.62%	CV = 5.27%

Symbols as defined in Table (2).

Table 7. Mean leaf potassium content (%) of ratoon as affected by treatments

Variety	Fertilizer rate		4 months from planting Soil series			MVE	6 months from planting Soil series			MVE	8 months from planting Soil series			MVE	10 months from planting Soil series			MVE
	K	P	Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu		Dinder	Nasr	Hagu	
		P0	1.64	1.44	1.38		1.48	1.54	1.38		1.30	1.64	1.45		1.23	1.41	1.50	
	K0	P1	2.12	1.50	1.59		1.65	1.60	1.64		1.53	1.90	1.55		1.48	1.54	1.73	
		P2	2.15	1.70	1.74		1.64	1.75	1.80		1.43	2.04	1.60		1.40	1.65	1.84	
		P0	1.90	1.88	1.64		1.72	1.93	1.72		1.58	1.88	1.66		1.47	1.48	1.80	
Co 6806	K1	P1	2.50	1.75	1.80	1.79a	1.90	2.43	1.90	1.74a	1.80	1.96	1.58	1.65a	1.63	1.65	1.88	1.59a
		P2	2.35	1.82	1.60		1.58	1.85	1.75		1.48	2.00	1.58		1.45	1.61	1.73	
		P0	2.03	1.85	1.70		1.68	1.90	1.70		1.60	1.89	1.53		1.55	1.60	1.75	
	K2	P1	2.35	1.60	1.50		1.61	1.63	1.66		1.58	1.79	1.50		1.50	1.57	1.66	
		P2	2.06	1.70	1.52		1.75	2.00	1.65		1.68	1.90	1.62		1.48	1.75	1.78	
		P0	1.50	1.52	1.15		1.37	1.56	1.48		1.20	1.45	1.30		1.29	1.23	1.45	
	K0	P1	2.00	1.75	1.51		1.61	1.76	1.67		1.33	1.70	1.58		1.38	1.53	1.60	
		P2	2.10	1.75	1.58		1.60	1.80	1.74		1.38	1.66	1.50		1.44	1.50	1.70	
		P0	1.75	1.71	1.34		1.48	1.78	1.70		1.30	1.77	1.50		1.45	1.48	1.71	
Co 527	K1	P1	2.40	1.95	1.62	1.74b	1.73	2.10	1.86	1.68b	1.50	1.89	1.76	1.56b	1.65	1.57	1.76	1.56b
		P2	2.00	1.65	1.45		1.56	1.75	1.53		1.38	1.71	1.51		1.43	1.35	1.72	
		P0	1.88	1.85	1.49		1.70	1.90	1.75		1.40	1.87	1.54		1.63	1.68	1.65	
	K2	P1	2.30	1.82	1.58		1.61	1.90	1.75		1.40	1.70	1.47		1.50	1.55	1.85	
		P2	1.98	1.70	1.44		1.48	1.81	1.52		1.48	1.67	1.47		1.57	1.52	1.76	
MSE			2.04a	1.72b	1.53c		1.62c	1.83a	1.68b		1.47c	1.80a	1.54b		1.47c	1.54b	1.72a	
			Main K effect				Main K effect				Main K effect				Main K effect			
			K0	K1	K2		K0	K1	K2		K0	K1	K2		K0	K1	K2	
			1.67b	1.82a	1.80a		1.62c	1.79a	1.72b		1.53b	1.65a	1.62a		1.49c	1.60b	1.63a	
			Main P effect				Main P effect				Main P effect				Main P effect			
			P0	P1	P2		P0	P1	P2		P0	P1	P2		P0	P1	P2	
			1.65c	1.87a	1.77b		1.65c	1.78a	1.70b		1.56b	1.64a	1.62a		1.52b	1.61a	1.59a	
			Variety SE = ±0.016				Variety SE = ±0.009				Variety SE = ±0.012				Variety SE = ±0.009			
			Soil, K and P SE = ±0.019				Soil, K and P SE = ±0.011				Soil. K and P SE = ±0.014				Soil, K and P SE = ±0.011			
			CV = 8.10%				CV = 5.01%				CV = 6.51%				CV = 5.02%			

Symbols as defined in Table (2).

significantly except when the plant was 6 months old. The addition of potassium to ratoon reflected a significant increase in leaf phosphorous content relative to the control. This was true when potassium fertilizer was applied at 86-kg K_2O/ha (K1), whereas application of potassium fertilizer at the rate of 172 kgK_2O/ha (K2) did not show any effect on the level of leaf phosphorous. These results were in agreement with those of **Randall, *et al* (1997)**. The level of leaf phosphorous obtained in this study ranged from 0.05-0.14, 0.08-0.14 and 0.05-0.12% for Dinder, Nasr and Hagu soil respectively. These ranges were considered low with reference to the standard concentration 0.15% **(Wolf, *et al* 1985)**. Hagu soil recorded the least leaf phosphorous content because it has the capacity to fix more phosphorous compared with other soil series **(El-Fadil, 1971)**.

Potassium

Addition of potassium fertilizer manifested a significant effect on leaf potassium content in both plant cane and ratoon **(Tables 6 and 7)**. A positive effect on leaf-K was observed for potassium phosphorous interaction in both plant cane and ratoon experiments. This may be attributed to the synergetic interaction between potassium and phosphorous and/or to the improved root system due to the added phosphorous which means more soil volume for the plant to exploit for potassium **(El-Essawi *et al* 1995 and Elmahi *et al* 2002)**. The soil types showed significant differences in leaf potassium level that could be attributed to the differences in potassium fixing capacity of these soils. According to **El-Fadil (1971)**, the clay mineral was abundantly montmorillonite in Dinder and Nasr whereas Hagu soil was mostly Kaolinitic. Therefore, the expected fixation pattern should be in the order of Dinder > Nasr > Hagu. The measured values of leaf potassium of plant grown on Dinder, Nasr and Hagu soil ranged between 1.23-2.35, 1.11-2.41 and 1.3-2.24%, respectively. These values can be considered medium to high for the three soil series **(Wolf, *et al* 1985)**.

Conclusions and recommendations

In conclusion, leaf-N, P and K of sugarcane and its ratoon were significantly improved by phosphorus and potassium fertilizers and it was evident that Nasr series surpassed Dinder and Hagu series in leaf-P content. The present study revealed that higher rates of potassium should be recommended on Co 6806.

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حوليات العلوم الزراعية
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تأثير السماد الفوسفوري والبوتاسي علي محتوى أوراق عينتين من قصب السكر المزروع في ثلاثة أنواع من الترب في السودان

[٤٤]

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أجريت تجربة حقلية لموسمين متتالين (١٩٩٨ – ١٩٩٩) بموقع شركة سكر سنار (خط عرض ٣٣ ١٣° شمال وطول ٣٧ ٣٣° شرق)، لدراسة تأثير التسميد البوتاسي والفوسفوري علي محتوي نبات قصب السكر وخلفته من النيتروجين والبوتاسيوم والفوسفور. المعاملات تشمل ثلاثة مستويات من البوتاسيوم (صفر و٧٢ و ١٣٣ كجم للهكتار). وثلاث مستويات من الفوسفور (صفر و٢٩ و٥٨ كجم للهكتار). أستعمل كلوريد البوتاسيوم كمصدر للبوتاسيوم والسوبرفوسفات الثلاثي كمصدر للفسفور. أجريت هذه التجربة علي عينتين من قصب السكر (Co 6806 & Co 527) مزروعة في ثلاثة أنماط من التربة (هجو وناصر ودندر). أتبع في تنفيذ التجربة التصميم العشوائي الكامل في ثلاثة مكررات.

بدأ جمع عينات النبات للتحليل بعد أربعة شهور من الزراعة واستمر جمع عينات النبات كل شهرين

بدأ جمع عينات النبات للتحليل بعد أربعة شهور من الزراعة واستمر جمع عينات النبات كل شهرين حتى الشهر العاشر من الزراعة. أوضحت النتائج أن التركيب المعدني للنبات قد تأثر معنويا بالمعاملات. وقد كان محتوى ورق النبات من النيتروجين مرتفعا في العينات الأولى ٣,٢٣% وبدأت تنخفض بتقدم موسم النمو ١,٨%، هذا المستوى من النيتروجين يعتبر مرتفعا إلي منخفض قياسا بالمستويات المثلى. وكان محتوى عينات قصب السكر من النيتروجين أعلى منه في الخلفة. نمط التربة ناصر أعطى أعلى محتوى من النيتروجين في الورقة يليها نمط تربة الدندر وأدناه هجو.

المحتوى النيتروجيني في عينة قصب السكر Co 6806 كان أكبر منه في العينة Co 527. و يعتبر محتوى أوراق النبات من الفوسفور منخفضا نسبيا قياسا بالمستويات المثالية حيث يتراوح بين ٠,٥٥-٠,١١٦%. وتحتوي العينة Co 6806 علي كمية فوسفور أكثر من العينة Co 527. وكان محتوى الورقة من الفوسفور والبوتاسيوم في الخلفة أعلى منه في قصب السكر مما يدل على الأثر المتبقي للسماد الفوسفوري والبوتاسي. وكان محتوى الأوراق من البوتاسيوم في مستوى غير كافي (١,٣٣- ٠,٠٤).

وقد أوضحت الدراسة أن هناك ارتفاع مقدر في محتوى أوراق النبات من النيتروجين، والفوسفور والبوتاسيوم في قصب السكر والخلفه.

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