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Effect of Different Levels of Potassium Sulphate Fertilizer on Growth, Yield and Quality of Sugarcane Ratoon one in Two Sites in Sudan

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Abstract:
Research have been conducted in two sites in Sugarcane Research Center Farm in Guneid-Sudan from January, 2019 to September, 2020 in two sites. The study aimed to evaluate the effect of potassium sulphate fertilizer doses on the growth of sugarcane ratoon one. The variety tested was Co 6806. The treatments consist of five doses of potassium sulphate (SOP) fertilizer which contains (50%K_2O and 18%S); K_1: 0.0, K_2: 40, K_3: 80, K_4: 120 and K_5: 160 kg SOP kg ha^{-1} arranged in randomized complete block design (RCBD) replicated three times. The results obtained that there was a significant effect on sugarcane ratoon one growth, yield and all quality parameters due to the application of different levels of potassium sulphate fertilizer in the two sites. Statistically, the treatment K_3: (80 SOP kg ha^{-1}) recorded significantly the highest cane and sugar growth, yield and quality values compared to the other potassium sulphate levels and the control in the two different experimental sites.

Keywords: *plant cane Ratoon, Fertilizer, Potassium sulphate, Doses, growth*

Introduction

Sugar is considered as one of the most important strategic commodities and bio-energy crop due to its phenomenal dry matter production capacity for people all over the world (Surendran *et al.*, 2016). Ratooning is a practice of growing full crop of sugarcane (*Saccharum officinarumL.*) from sprouts of underground stubbles left in the field after harvest of the plant crop. Planted sugarcane as well as, ratoons are highly exhaustive crops having higher demand for nitrogenous fertilizer due to shallow root system, decay of old roots, sprouting of stubble buds and immobilization of nitrogen. It is, therefore necessary to use 20 to 25% more nitrogenous fertilizer over the recommended dose of nitrogen for ratoon crop (Lal and Singh, 2008). Shukla *et al*. (2013) reported that ratooning in sugarcane saves the cost of seedbed preparation, seed material and planting operations. However, most often ratoon crop yields are lower than the plant crop. Many environmental, cultural, and biological factors are associated with stubble decline. Ratoon keeping is 25-30% economical than plant crop and get ready for harvest before plant crop with supplementary advantage of better juice quality and sugar recovery Yadav,

(1991). Potassium (K) is commonly called potash. The main sources of potassium were muriate of potash (MOP), sulfate of potash (SOP). Potassium sulfate is an excellent source of nutrition for plants because both Potassium and sulphur are essential nutrients and improves yield, quantity, and taste and enhances shelf life (Kumar and Kumar, 2008). Potassium, is considered as an important element in restoring the productivity of sugarcane ratoon, Weber et al., (2002). Sugarcane has a very high K demand because of its importance in physiological processes such as enzyme activation, stomatal activity, photosynthesis, sugar, water and nutrient transport, and protein and starch synthesis (Prajapati *et al,* 2012). It is documented that potassium has a key role in sugarcane potassium fertilizer which is critical for sugarcane nutrition responsible for uptake of other nutrients enhanced growth rate and yields therefore; they are considered important elements in worldwide food production (Ali, et al., 2018). This research aimed to study the effect of potassium sulphate fertilizer doses on the growth of sugarcane ratoon one cane.

Materials and Methods:

Experimental site: Two field experiments in two different experimental sites were conducted at Sugarcane Research Center Farm at Guneid area, (33^{o} 19″ E, 14^{o} 47″ N), during season 2019-2020. The soil of the experimental site was classified as Suleimi soil series which is clayey Smectitic alluvium, clayey vertisol with moderate chemical fertility. The variety tested was Co 6806.

2.2Method of establishing cane ratoon:

The agronomic practices to raise the cane ratoon one crop which includes after the removal of the plant cane crop, the remaining trash was raked out and the stubble was given a first irrigation before treatments after three days from harvesting were applied as commonly used for growing sugarcane and carried out according to the recommendation of the Sudanese Sugar Company..

Potassium fertilizer source: Potassium sulphate (SOP) fertilizer which contains (50%K_2O and 18%S) was distributed evenly to the experimental units using the broadcasting application method.

Experimental design: Experimental design was a Randomized Complete Block Design (RCBD). The treatments involved five levels of potassium sulphate fertilizer replicated three times. The time of application is 150 days after planting.

Potassium sulphate level treatments: K_1:0.0**,** K_2:40, K_3: 80, K_4: 120 and K_5: 160 kg K_2O ha^{-1}.

Cultural practice

Weed control: A knapsack sprayer with a capacity of 16 liter was used for applying herbicides. The sprayer fitted with a single polijet nozzle, giving a swath of 1.5 meters, was firstly tested by applying pure water on sensitive papers. The nozzle was positioned over the center of the furrow so that the spray width extended from ridge top to next ridge top to insure complete and even coverage. The spray delivery rate was 192 L/ha at a pressure of 1.5 bars. All herbicides treatments were applied before 2^{nd} irrigation. The hand-weeded plots received two weeding per month and kept weed-free till full cane canopy was reached. In the un-weeded plots the weeds were left un-weeded until full cane canopy was reached.

Irrigation: Subsequent irrigations were applied at 10 days intervals except during hot and rainy periods when the interval was adjusted as required. Irrigation stopped for 30 days before harvesting to facilitate the harvesting operations in the field and increase sugar concentration.

Fertilizing:

200 kg urea per feddan was applied at 25 days from ratoon establishment. Potassium sulphate fertilizer different levels

treatments in the study applied at 4 month age during tillering period which represent the suitable time for sugarcane potassium fertilization

Hilling up: At 30 days after establishing ratoon hilling up process was made in the two different experimental sites to reshape the ridges for good irrigation and good aeration.

Harvesting: Plant cane usually harvested at 12month age manual or mechanical. The plant cane experiment in the two sites harvested at 5/1/2021 for (Site one) and 10/1/2020 for (Site two).

Parameters

Potassium concentration data collection: Potassium concentration was determined (mg/kg) from leaf sheath samples taken at 60, 90, 120, 270 and 360 days after planting. The samples weighed and then oven dried and then poured in a Willey Mill to pass through 2 mm sieve and the samples were used to determine potassium concentration by using wet digestion method in which dilute acid ($HN0_3$: $HCI0_4$) used with the help of Flame Photometer Tandon, (1998).

Cane yield and quality parameters: Cane yield parameters viz; cane length (cm), cane diameter (cm), number of millable stalks per hectare and cane yield ton cane per hectare (ton/ha) were recorded. The sugar cane juice quality parameters which including sucrose percent (pol %), purity % cane juice and sugar yield tons sugar per hectare (tons/ha) were determined from juice analyzed according to ICUMSA ,Plews, (1997) methods of analysis.

Statistical analysis: Experimental data collected were analyzed statistically using analysis of variance (ANOVA) technique to evaluate the differences among treatments, and the means were separated using the least significant difference (LSD) at the 5% level of significance (Gomez and Gomez, 1984)

Results and Discussion:

The experimental results data in Fig.1, and 2 showed that potassium-concentration in the plant cane and ratoon leaf sheath start with high K concentration values at 60 days age and then decreases at 90 and 120 days after planting depending on the soil solution before the addition of different potassium sulphate fertilizer levels which added to the soil at 150 days from planting date. Most of potassium is absorbed in canopy completion period or tillering. After the application of K_2SO_4 fertilizer levels at 120 days age potassium-concentration in the ratoon leaf sheath began to increases gradually and then began to decrease with the increasing of the crop age till it reached its less potassium - concentration values at the harvesting. The results obtained from the study agreed to that of Flores, *et al*., 2014, Who reported linear increment in contents and K accumulate in both leaves and stalks of ratoon as a result of K_2O doses applied to the soil. Velasco, *et al.* (2012) found that most of potassium is absorbed in canopy completion period or tillering where sugarcane starts accumulating most of the dry matter. Also Medina *et al.* (2013) confirmed that a higher concentration of potassium at the beginning of plant development and over time reaching a lower concentration in the adult plant at harvesting. After the addition of K_2SO_4 fertilizer levels at the exact time K- concentration began to increase and then decreases with the increasing of the crop age till it reached its less K-concentration values at harvesting.

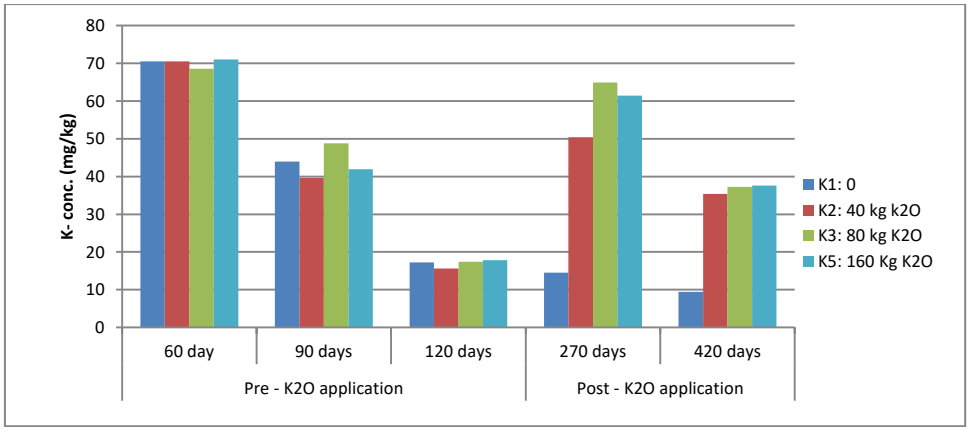

Fig. 1: Potassium concentration (mg/kg) in plant cane leaf sheath

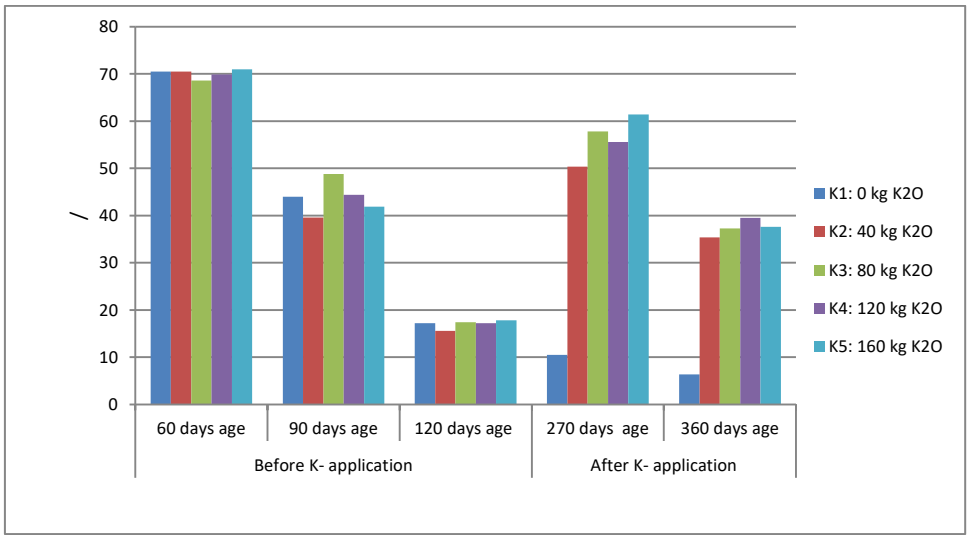

Fig. 2: Potassium concentration (mg/kg) in leaf sheath

Table 1, presented the effect of different potassium sulphate fertilizers level on ratoon growth; plant hight, number of internodes during 3,6 and 9 months the results obtained non significant different for all this parameters in the different sites. Bahatt *et al*., 2021 showed that the average number of surgarcane shoots re – sprouting, and internode per cane were slight higher but not different statistically.

Table (1): Effect of different potassium sulphate fertilizer levels on ratoon one growth parameters

Exp. Site	Treatments	Plant height (cm)			No of tillers/m^2			No of internodes		
		3 month age	6 month age	9 month age	3 month age	6 month Age	9 month Age	3 month age	6 month Age	9 month Age
Site 1	K_1	21.8a	72.9a	168.8a	17.8a	19.0a	19.3a	0.0 a	5.7a	14.5a
	K_2	18.7a	73.8a	170.0a	19.8a	20.0a	18.8a	0.0 a	5.5a	14.5a
	K_3	18.9a	83.8a	187.3a	19.4a	19.7a	21.4a	0.0 a	5.8a	14.0a
	K_4	20.7a	81.0a	175.0a	18.9a	18.9a	18.7a	0.0 a	5.4a	14.0a
	K_5	19.3a	79.4a	175.0a	19.3a	19.3a	19.7a	0.0 a	5.2a	13.5a
	Mean	19.9	76.2	175.2	19.0	19.4	19.8	0.0	5.5	14.1
	CV%	7.3	9.8	6.0	4.2	3.6	7.3	0.0	8.6	6.5
	LSD(0.05)	4.0	20.8	29.1	2.2	1.9	3.9	0.0	1.3	2.6
Site 2	K_1	22.5a	88.1a	175.9a	17.4a	18.7a	19.3a	0.0 a	5.6a	13.7a
	K_2	20.2a	87.6a	178.7a	17.7a	18.9a	19.8a	0.0 a	5.5a	14.9a
	K_3	24.6a	90.4a	195.5a	18.0a	19.0a	20.5a	0.0 a	6.2a	14.8a
	K_4	23.9a	88.1a	183.4a	17.8a	18.6a	19.0a	0.0 a	6.0a	13.4a
	K_5	22.9a	85.6a	181.6a	18.3a	19.1a	20.2a	0.0 a	6.8a	13.5a
	Mean	22.8	87.2	183.0	17.9	18.9	19.9	0.0	5.8	14.0
	CV%	7.1	3.4	5.3	2.3	1.7	3.2	0.0	8.1	5.8
	LSD(0.05)	4.5	8.0	26.7	1.1	0.9	1.6	0.0	1.3	2.3

five levels of potassium sulphate fertilizer K_1:0.0**,** K_2:40, K_3: 80, K_4: 120 and K_5: 160 kg ha^{-1}.Means with the same letters are not significantly different at LSD5%.

Experimental results data in Table 2. Showed that there was a significant difference between different potassium sulphate fertilizer levels treatments in all ratoon yield parameters except for ratoon diameter. The treatment K_3: recorded the highest ratoon length values (231.7 and 220.9 cm) and K_2: (204.9 and 195.2 cm), K_4: (208.2 and 187.0 cm), K_5: (192.6 and 170.5 cm), and K_1: (the control) - recorded the lowest cane length values (203.8 and 185.2 cm) in the two different experimental sites respectively. Experimental results data in Table (2) showed that there was a significant difference between different potassium sulphate levels on the number of millable stalks per hectare in the two different experimental sites. K_3: recorded the highest number of millable stalks values (104.0 and 128.5), K_2: (88.0 and 117.2), K_4: (90.0 and 119.9), K_5: (86.0 and 118.1) K_1: the control, (81.0 and 118.1) in the two different experimental sites respectively. Experimental results data in Table (2) also, showed that there was a significant difference between different potassium sulphate levels on the ratoon yield in the two different experimental sites. The treatment K_3: recorded the highest ratoon yield values (102.4and 103.8 ton cane/ha), K_2: (88.8 and 97.2 ton cane/ha), K_4: (94.8 and 92.4 ton cane /ha), K_5: (87.7 and 93.1 ton cane/ha) K_1: (86.4 and 93.5 ton cane/ha) in the two different experimental sites respectively. Kadarwati (2020), concluded that 180 kg \ha of potassium in form of K_2O increased sugarcane stalk diameter, weight and yield. Ahmed et al.,(2012) recommended 90kg\ha to get heavier stalk weight. The experimental results obtained from this study confirmed to those of Kolln *et al.* (2013) who has observed that increases in soil potassium content increased sugarcane productivity in Brazil. Also, in a study by El-tilib *et al*, (2004) indicated that potassium application affected significantly on plant density, stalk diameter, cane and sugar yield. These results are in agreement with Jafarnejadi (2013), Khan *et al.,* (2005) and Kadarwati,(2020) who found that optimum and balanced use of potasim fertilizers in different forms improved cane yield and quality of different cultivars and gave maximum economical benefit to the farmers. This is due to fact that K fertilizer improved the efficiency of water and nitrogen use of sugarcane roots, Saleem, et al., (1995) and Basha and Rao, (1980).

Table 2 : Effect of different potassium sulphate fertilizer levels on ratoon growth

Treatments	Cane length (cm)		Cane diameter (cm)		Number of millable stalks (x1000 per hectare)		Cane yield (Tons per hectare)	
	Site1	Site2	Site1	Site2	Site1	Site2	Site1	Site2
K_1	203.8^{b}	185.2^{b}	2.0^{a}	2.1^{a}	81.0^{b}	118.3^{b}	86.4^{b}	93.5^{ab}
K_2	204.9^{b}	195.7^{b}	2.1^{a}	2.1^{a}	88.0^{ab}	117.2^{b}	88.8^{b}	97.2^{ab}
K_3	231.7^{a}	220.9^{a}	2.1^{a}	2.2^{a}	104.0^{a}	128.5^{a}	102.4^{a}	103.8^{a}
K_4	208.2^{b}	187.0^{b}	2.0^{a}	2.2^{a}	90.0^{ab}	119.9^{b}	94.8^{ab}	92.4^{ab}
K_5	208.0^{b}	192.6^{b}	2.0^{a}	2.1^{a}	86.0^{ab}	118.1^{b}	87.7^{b}	93.1^{ab}
Mean	211.4	196.3	2.0	2.1	94.6	124.0	92.2	94.2
CV%	7.8	7.8	4.9	4.6	10.6	8.4	9.4	8.7
LSD (P< 0.05)	21.1	18.7	0.2	0.2	10.9	11.8	7.1	8.6

five levels of potassium sulphate fertilizer K_1:0.0**,** K_2:40, K_3: 80, K_4: 120 and K_5: 160 kg ha^{-}
Means with the same letters are not significantly different at LSD5%.

Experimental results data in Table (3) showed that there was no significant difference between different potassium sulphate levels on pol% cane juice, while there was a significant difference between different potassium sulphate levels on sugar yield in the two different experimental sites. The treatment K_3: recorded the highest sugar yield values (9.6 and 9.4 ton sugar/ha) K_4: (7.6 and 8.1 ton sugar/ha), K_5: (8.4 and 8.1 ton sugar/ha), K_2: (8.1 and 8.4 ton sugar/ha), K_1: recorded the lowest sugar yield values (7.3 and 7.3 ton sugar/ha) in the two different experimental sites respectively. According to the experimental results, potassium sulphate fertilizer application was really effective in sugar formation and increasing the percentage of sugar in plant cane crop. The results achieved for cane quality characters similar to that of (Bhatt *et al*.,2021) who recommended that most quality parameters were significantly higher for plants receiving any of K treatment than control, the greatest for plants treated with 80 kg K_2O ha^{-1} in both sites. Phonde *et al.* 2005, Fotouhi, 2003 Mahmoud, *et al.* 2008 Meyer, 2013) observed that on sugarcane quality; adequate potassium supply ensured a higher sugar yield and was the probable reason for increasing in sugar yield. (Jafarnejadi, 2013) reported that potassium improved purity quality and reduced fiber content. (Weber *et al.,* 2002) and Kadawati 2001, found that potassium is essential to recover ratoon sugarcane yields. in general obtained that K fertilization will determine the quality of sugarcane production instead of the growth components.

Table3: Effect of different potassium sulphate levels on ratoon one quality

Treatments	Parameters: Pol% cane		Purity % cane		Fiber %		Sugar yield	
	Juice		Juice		Cane		Tons per hectare	
	Site1	Site2	Site1	Site2	Site1	Site2	Site1	Site2
K1	11.7^{a}	12.8^{a}	86.6^{d}	82.8^{b}	18.6^{a}	16.9^{a}	7.3^{b}	7.3^{c}
K2	11.0^{a}	12.8^{a}	87.7^{cd}	84.9^{ab}	18.4^{a}	16.5^{a}	8.1^{ab}	8.4^{b}
K3	11.9^{a}	12.7^{a}	90.9^{a}	86.7^{a}	18.9^{a}	15.4^{a}	9.6^{a}	9.4^{a}
K4	11.5^{a}	12.8^{a}	89.4^{ab}	84.5^{ab}	18.1^{a}	16.2^{a}	7.6^{b}	8.1^{b}
K5	11.6^{a}	12.8^{a}	88.9^{bc}	83.8^{b}	18.4^{a}	15.6^{a}	8.4^{ab}	8.1^{b}
Mean	11.5	12.8	86.7	84.6	18.5	16.5	8.4	8.3
CV%	4.0	4.2	3.1	1.9	6.0	4.8	9.6	11.7
LSD (P< 0.05)	0.6	0.4	1.8	2.7	0.6	1.0	1.1	0.8

Five levels of potassium sulphate fertilizer K_1:0.0**,** K_2:40, K_3: 80, K_4: 120 and K_5: 160 kg ha^{-}. Means with the same letters are not significantly different at LSD5%.

Conclusion

Sudan as one of the main sugarcane producer among Arab and African countries, great attention must give to it. The application of fertilizers is one of this important cultural practices to improve it is growth yield and quality. Application of different doses of potassium sulphate fertilizer concluded that the treatment K_3: (80 SOP kg ha^{-1}) recorded significantly the highest cane and sugar growth, yield and quality values compared to the other potassium sulphate levels and the control in the two different experimental sites.

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أثر مستويات مختلفة من سماد البوتاسيم سلفات علي نمو وانتاجية و جودة خلفة قصب السكر في موقعين مختلفين في السودان.

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المستخلص

تم اجراء البحث في موقعين بمزرعة مركز ابحاث قصب السكر في الجنيد بالسودان من يناير 2019 الي سبتمبر 2020. هدفت الدراسة الي تقييم تاثير جرعات سماد كبريتات البوتاسيم علي نمو خلفة قصب السكر . الصنف الذي تم اختبارة هو .Co 6806 تتكون المعاملات من خمس جرعات من سماد كبريتات البوتاسيم الي يحتوي علي ($50\%K_2O$, $18\%S$); K_1: 0.0, K_2: 40, K_3: 80, K_4: 120 and K_5: 160 kg SOP kg ha^{-1} تم تصميم التجربة بالقطاعات العشوائية الكاملة مكررة ثلاث مرات.

أظهرت النتائج أثار معنوية علي نمو وأنتاج خلفة قصب السكر وجميع معاملات الجودة في الموقعين وأظهرت المعاملة 80K3 كم\اللهكتار أعلي معدل للنمو وجودة السكر مقارنة بباقي المعاملات.