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THE EFFECT OF DIFFERENT SOURCES, RATES OF NITROGEN AND PHOSPHORUS FERTILIZERS ON THE YIELD AND QUALITY OF SUGARCANE

Agricultural Science

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ABSTRACT

Field experiments were conducted on the Sugarcane Research Center Farm at Guneid during seasons 2015/2016 and 2016/2017 as plant cane crop. The soil was clayey vertisol with moderate chemical fertility. The objective of the study was to evaluate the effect of different sources, rates of nitrogen and phosphorus fertilizers on the yield and quality of sugarcane. The experimental design was a randomized complete block design (RCBD) with seven treatments and four replications. The results showed a significant differences between treatments at (P>0.05) level for cane and sugar yield (tons/ha).The highest cane and sugar yield were recorded from treatment (T2) which contain di-ammonium phosphate (DAP) in combination with ammonium sulphate (AS) while the lowest cane and sugar yield (tons/ha) were recorded from the control (T1) which contain triple super phosphate (TSP) in combination with urea in the two seasons respectively. All treatments which contain di-ammonium phosphate (DAP) in combination with Ammonium sulphate (AS) fertilizers recorded higher cane and sugar yield (ton/ha) than the control (T1) in the two seasons of the study.

KEYWORDS

Sugarcane, Triple super phosphate, Urea, Di-ammonium phosphate, Ammonium sulphate

INTRODUCTION

Sugarcane (*Saccharum spp*) is a C-4 prennial plant belong to the grass family Poaceae. It is a tropical and sub-tropical plant widely grown around the world within 36.7^0 North and 31^0 South of the Equator. Sugarcane can be grown in a wide variety of soil types. The best climate for growing dry land sugarcane is one with two distinct seasons: one warm and wet, for encouraging germination and vegetative development, followed by a cool, dry season to promote ripening and consequent accumulation of sucrose in the stalks. Moreover, it is the major source of white sugar and a source of basic raw material for various agro–based industries. In this sense, approximately 79% of the world sugar is produced from sugar cane, *(Czarnikow, 2016)*.

Sugarcane is known as a heavy feeder crop that depletes the soil of essential nutrients. It is reported that an average crop producing 100 ton/ha of sugarcane takes up nearly 208 kg N, 53 kg P, 280 kg K, 6.3 kg Fe, 1.2 kg Mn, 0.6 kg Zn and 0.2 kg Cu from soil *(Malavolta,1994*). In most countries, addition of fertilizers mainly nitrogen and phosphorus improves cane and sugar yield, available reports indicate that N fertilization improves cane elongation, plant population and cane yield while P and K have effect on rate of tillering and sucrose accumulation *Husingi, (1993)*. The world recommended rates of Nitrogen fertilizer for sugarcane production vary between 45 and 300 kg N/ha. *Srivastava et al, (1992)* reported that, all mineral sources of N are considered to be equally effective and should be selected on the basis of price per unit of N and convenience of application. Urea with its relatively higher nitrogen content (46%), easy handling, safe storage and transportation is the main N-source used for sugarcane and other crops in the Sudan *(Mukhtar, 2008)*. Ammonium Sulphate (AS) 21% N and 24% S was one of the first and most widely used nitrogen fertilizers for crop production. In general, losses tend to be considerably lower from ammonium sulphate than that from urea therefore, other sources of fertilizes with less loss of N are being considered.

Phosphorous, is essential to the formation of a vigorous and healthy root system, stimulates tillering and influences favorable better growth and thereby better yield and juice quality *(Bokhtail and Sakauri, 2003)*. Phosphorus absorbed by the plant roots in primary and secondary orthophosphate ions $H_2PO_4^-$ and HPO_4^{2-}.Di-ammonium phosphate (DAP) is most widely-produced phosphate fertilizer, a source of phosphate and nitrogen for soil application, 18% N and 46% P_2O_5 its phosphate is effective as that in any other phosphate source, has excellent handling and storage properties, and the low cost of nitrogen in DAP makes it a cost effective source of nitrogen if Phosphorus is also required. In the Sudanese Sugar Company Farms the common practice fertilizers were 129 kg N/ha as a source of N plus 238 kg TSP as a source of P. *Freney et al,(٢٠٠4)* reported that losses of N by volatilization ranged from 17-39 % for surface applied urea, compared to less than 1.8 % for sulfate of ammonia. Regarding to available P in the soil from TSP fertilizer it was low; this might be due to P-fixation phenomenon which results in chemical compounds not available for sugarcane. Recently, the major industry fertilizers Companies in the world directed their planning to produce DAP fertilizer more than TSP fertilizer *IPNI, (2012)*.

The main objective of the study was to evaluate the effect of different sources, rates of nitrogen and phosphorous fertilizers on the yield and quality of sugarcane.

MATERIAL AND METHODS

Site specifications: Field experiments were carried out during 2015/2016 and 2016/2017 within Guneid Sugarcane Research Centre farm (latitude 14° 52′, N and longitude 33° 19′ E). The climate is tropical aridic. Soils are Suleimi soil series which are clayey smectitic alluvium. Moderately suitable, of clay content 58–61%, bulk density 1.6–1.7 gm cm^{-3}, hydraulic conductivity 0.6–0.7 cm hr^{-1}, organic carbon 0.3–0.4 %, N 0.03–0.04, available P 0.9–3.0 mg P/kg soil, Exchangeable K 0.6–0.9 cmol$^+$/kg soil and CEC 58–61, and pH 8.1.

Plant material: The variety tested was Co 6806 which occupies about 90 % of the commercial sugar cane fields, for two seasons as plant cane crop.

Fertilizers: Triple Super Phosphate (TSP) incorporated with urea as a common practice applied in the Sudanese Sugar Company farms (SSCF) and di-ammonium phosphate (DAP), incorporated with ammonium sulphate (AS) in different optimum rates.

Experiment design: The experiment was laid out according to a Randomized Complete Block Design (RCBD) with four replications.

Experiment treatments:

T1: 238 kg TSP/ha + 129 Kg N/ha as urea (3 N) as control*
T2: 100 kg DAP/ha (46 kg P_2O_5+18 kg N) +111 kg N/ha as AS(3N).
T3: 100 kg DAP/ha (46 kg P_2O_5+18 kg N) +154 kg N/ha as AS(4N).
T4: 150 kg DAP/ha (69 kg P_2O_5+27 kg N) +102 kg N/ha as AS(3N).
T5: 150 kg DAP/ha (69 kg P_2O_5+27 kg N) +145 kg N/ha as AS (4N).
T6: 200 kg DAP/ha (92 kg P_2O_5+36 kg N) + 93 kg N/ha as AS (3N).
T7: 200 kg DAP/ha (92 kg P_2O_5+36 kg N) +136 kg N/ha as AS(4N).

* *The sugarcane fertilizing practice in (SSC).*

Data Collecting and analysis:

Cane yield: At harvest, for the two experiments the two inner rows were manually cut by cane knives, topped, cleaned from dead leaves and trash, weighed and the cane yield was determined. The following parameters were determined; plant height, plant thickness, number of millable stalks and cane yield (ton/ha).

Yield quality: From 10 stalks cane quality was determined according to *ICUMSA,(1994)*. The following parameters were determined: Pol % cane, estimated recoverable sugar ERS **%** and sugar yield (ton/ha).

Statistical analysis: Data collected was analyzed statistically through SAS Statistical software, 1997. (SAS Institute Inc., SAS Campus Drive, Cary, NC, USA 27513).The analysis of variance with Anova table, and the least significant difference (LSD) tests were employed at ($P \geq 0.05$) to compare the significance among the treatment means.

RESULTS AND DISCUSSION

Table (1): The effect of different sources, rates of N and P fertilizers on cane yield and yield components

Treatments	Plant height (cm)		Plant Thickness (cm)		Plant population (thousand/ha)		Cane yield (ton/ha)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1 :238 kg TSP + 3N (urea)	261.6 b	243.4 b	2.4 a	2.2 b	140.8 a	140.9 a	131.9 b	139.1 c
T2 :100 Kg DAP + 3N (AS)	293.4 a	260.9 ab	2.4 a	2.3 ab	148.5 a	152.0 a	160.9 a	164.1 a
T3 :100 Kg DAP + 4N (AS)	305.9 ab	274.8 a	2.2 b	2.3 ab	145.3 a	145.3 a	141.5 ab	153.2 ab
T4 :150 Kg DAP + 3N (AS)	286.8 ab	249.8 b	2.3 ab	2.3 ab	149.8 a	151.2 a	153.6 ab	149.4 ab
T5 :150 Kg DAP + 4N (AS)	288.6 ab	251.1 b	2.3 ab	2.4 a	144.3 a	153.6 a	152.6 ab	149.5 ab
T6 :200 Kg DAP + 3N (AS)	295.9 ab	262.8 ab	2.3 ab	2.2 b	151.5 a	143.6 a	143.2 ab	146.3 bc
T7 :200 Kg DAP + 4N (AS)	299.2 ab	263.0 ab	2.3 ab	2.3 ab	146.5 a	137.6 a	147.6 ab	152.3 ab
Mean	290.2	258.0	2.3	2.3	146.7	147.0	146.5	150.6
CV%	9.0	5.4	4.3	3.9	6.6	7.6	12.7	4.3
LSD (P > 0.05)	38.9	20.7	0.15	0.13	17.3	16.5	26.4	9.7

The effect of different sources, rates of N and P fertilizers on cane yield and yield components

Data presented in Table (1) showed that there were a significant differences between treatments in cane yield and yield components at ($P \leq 0.05$) level except for plant population (thousand/ha). The highest and the lowest plant height 305.9- 274.8 and 244.1-246.8 (cm) values were recorded with the application of T3 and T1 (control) in the two seasons respectively. All treatments in the study contain DAP in combination with AS fertilizers; T3, T4, T5, T6 and T7 recorded plant height (cm) higher than the control T1. The highest and lowest Plant thickness values 2.4–2.4 and 2.2-2.2 (cm) were recorded with the application of T1 (control), T2 and T5 and T3, T6 for the two seasons respectively. These results similar to *Bokhtiar et al. (2002)* who reported that cane height and cane thickness increased progressively with application of NPK at 200–80–160 kg ha[1]. The highest and the lowest plant population values 148.5–152.0 and 140.8–140.9 (thousand/ha) were recorded with the application of T2 and T1 (control) in the two seasons respectively. The highest and lowest cane yield 160.9-164.1 and 129.0-139.1 (tons/ha) were recorded with the application of T2 and T1 (control) in the two seasons respectively. All the other treatments in the study T3, T4, T5, T6 and T7 recorded cane yield (ton/ha) higher than T1 (control). Also, *Chaudhry and Chatta (2000)* noticed that maximum stripped cane yield of 71.1 ton/ha was reported when phosphorous was applied at the rate of 100 kg P_2O_5/ha in combination with 200 kg N/ha. The results of the study agree with *Abouna,(2007*) who recommended to apply 54.7 kg P_2O_5 ha^{-1} for the plant cane because there was no significant difference in cane yield between the tested phosphate rate of 54.7 kg P_2O_5 ha^{-1} and that of the normal P rate of 109.4 kg P_2O_5/ha.

Table (2): Effect of different rates, sources of N & P feretilizers on the cane quality

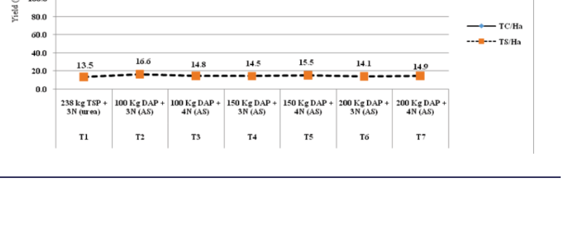
Treatments	Pol % cane		ERS % cane		Fiber % cane		Sugar yield (tons/ha)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
T1 238 kg TSP + 3N (urea)	13.7 abc	12.7 ab	11.2 ab	9.7 ab	15.1 a	15.6 a	13.5 b	13.5 b
T2 100 Kg DAP + 3N (AS)	14.2 ab	12.7 ab	10.6 ab	9.7 ab	15.3 a	16.5 a	17.3 a	15.9 a
T3 100 Kg DAP + 4N (AS)	14.5 a	12.6 ab	11.1 a	9.6 ab	15.2 a	16.2 a	14.9 ab	14.7ab
T4 150 Kg DAP + 3N (AS)	13.0 c	13.0 ab	9.4 c	9.8 ab	15.5 a	15.3 a	14.6 ab	14.3ab
T5 150 Kg DAP + 4N (AS)	13.8 abc	13.2 a	10.3abc	10.2a	15.3 a	16.7 a	15.8 ab	15.2ab
T6 200 Kg DAP + 3N (AS)	13.5 bc	12.4 b	10.1 bc	9.4 b	16.1 a	16.4 a	14.5 ab	13.7 b
T7 200 Kg DAP + 4N (AS)	14.1 ab	12.5 b	10.5 ab	9.5 b	15.0 a	15.6 a	15.3 ab	14.4ab
Mean	14.0	12.7	10.5	9.7	15.3	16.0	15.3	14.5
CV%	4.4	3.4	6.0	4.1	5.29	10.9	13.3	5.7
LSD (P ≤ 0.05)	0.9	0.6	0.8	0.6	1.2	2.6	2.9	1.2

Since, Di-ammonium phosphate (DAP) contain both N and P fertilizer as a source of P, if we added DAP in different rates; 100, 150 and 200 kg/ha this would add 18, 27 and 36 kg N/ha respectively which may be results in improving cane and sugar yield (ton/ha) happened due to urea-N losses which caused reduction in cane and sugar yield.

Effect of different sources, rates of N and P fertilizers on the cane quality:

As shown in Table (2), all the qualitative parameters, showed a least significant difference between treatments at ($P \leq 0.05$) level except for fiber % cane. The highest Pol % cane values 14.9 and 13.2(%) were recorded with the application of T1 (control) and T5 while the lowest Pol % cane values 13.0 and 12.4 (%) were recorded with the application of T4 and T6 in the two seasons of the study respectively. The highest ERS% cane values 11.2, 11.1, and 10.2 (%), were recorded with the application of T1 (control), T3 and T5 and the lowest ERS % cane value 9.4 (%) were recorded with the application of T4 and T6 in the two seasons of the study respectively. The highest fiber % cane values 16.1 and 16.7 (%) were recorded with the application of T5, T6 and the minimum fiber % cane values 15.1 and 15.3 (%) were recorded with the application of T1 and T4 in the two seasons of the study respectively. The highest sugar yield values 17.3-15.9 (tons/ha), was recorded with the application of T2 followed by the other treatments more than T1 (control) which gave the minimum sugar yield values 14.5-13.5 (ton/ha) in the two seasons of the study respectively. These results agree to those of *Mahar et al (2008),* who reported that, chemical source of fertilizer (NPK) at the rate of 225-112-168 kg ha^{-1} proved to be more effective to produce significantly greater plant height and thicker cane girth, more tillers, better brix, higher sugar recovery and maximum cane yield ha^{-1}**.**

Figure (1): Average cane and sugar yield (T/Ha) of the two seasons of the study



Average cane and sugar yield (T/Ha) of the two seasons of the study:

Data presented in Figure (1). Showed that, T2: (100 kg/ha DAP (46kg P_2O_5+18 kg N)+111 kg N/ha as AS (3N) which constantly gave highest average cane yield 162.5 (ton/ha), highest average sugar yield 16.6 (ton/ha) compared to T1(control): (238 kg/ha TSP (109.4 kg P_2O_5) +129 kg N/ha as urea (control) 3N which constantly gave the lowest average cane yield 135.5 (ton/ha).These results may be due to high losses of N by volatilization of urea which *Fereny, (2004)*, reported that N losses ranged from 17-39 % for surface applied urea, compared to less than 1.8 % for sulfate of ammonia, also may be due to the presence of 24% sulphur in ammonium sulphate (AS) fertilizer which caused reduction in the pH of the soil and help sugarcane to uptake more nutrients from the soil solution and may be due to P-fixation phenomenon which happened more in triple super phosphate (TSP) compared to di- ammonium phosphate (DAP) fertilizer which its phosphate is effective as that in any other phosphate source.

Conclusion:

- Based on the findings of the study, All treatments which contain di-ammonium phosphate (DAP) in combination with ammonium sulphate (AS) fertilizers recorded higher cane and sugar yield (ton/ha) than T1 (control) which contain triple super phosphate (TSP) in combination with (Urea) fertilizers in the two seasons of the study.
- There were no significant differences between di- ammonium phosphate (DAP) fertilizer optimum rates; 100, 150 and 200 (kg/ha) treatments in cane and sugar yield (ton/ha) in the two seasons of the study.

Recommendation:

Due to the excellent results achieved from this study constantly for two seasons as plant cane crop cycle we can recommend to apply di-ammonium phosphate (DAP) fertilizer at an optimum rate from 100, 150 and 200 kg (DAP/ha) which contain 46, 69 and 92 (kg $P_2O_{5)}$ plus 18, 27 and 36 kg additive nitrogen respectively as a good source of phosphorus in sugarcane fields in the Sudan.

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