HNSJ Humanities & Natural Sciences Journal
ISSN: (e) 2709-0833
www.hnjournal.net

Peer-Reviewed Journal
Indexed at: NSP - SJIF
Arabic Impact Factor 2020 = 0.44

RESEARCH TITLE

EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM FERTILIZERS ON GROWTH AND QUALITY OF SUGARCANE

Ekhlas Mohamedzein Musa Mohamedzein[1]

[1] Faculty of Agriculture, University of Sinnar, Sudan.

HNSJ, 2022, 3(6); https://doi.org/10.53796/hnsj3614

Published at 01/06/2022 **Accepted at 05/05/2022**

Abstract

A field experiment was carried out in season 2014-2015 at Sinnar Sugarcane Farm in Sinnar State, to study the response of different sugarcane varieties to fertilization. The treatments comprised three varieties namely Co 527, Co 997 and Co 6808, and three types of fertilizers namely nitrogen, phosphorous and potassium fertilizers. The experiment was laid out in a randomized complete block design with three replications. Parameters studied were growth parameters (internodes number, stalk height, stem diameter, plant density and yield), quality of cane (pol, fiber, Brix) and quality of juice (purity, pol, fiber, Brix). The results showed that, the three varieties (Co 257, Co 997 and Co 6808) were significantly responded to the fertilization by nitrogen, phosphorous and potassium. Internodes number, stalk height and stem diameter of the three varieties of cane significantly increased by potassium fertilizer than phosphorous and nitrogen fertilizers, while plant density and cane weight of the three varieties increased by phosphorous fertilizer compared to potassium and nitrogen fertilizers. The best growth of Co 6808 variety clear in increase by all fertilizers compared to Co 997 and Co 527 varieties. The pol and Brix of cane of the three varieties were not affected by all fertilizers, while the fiber increased by potassium and phosphorous fertilizer respectively. Fiber of cane Co 527, and pol and Brix of cane of Co 6808 were more affected by fertilization. Brix and pol of juice of all varieties were not affected by fertilization, while purity and fiber of juice of all varieties were significantly decreased by fertilization.

Key Words: Sugar cane, nitrogen, phosphorous, potassium, internodes, stalk, juice

عنوان البحث

أثر إضافة سماد النتروجين والفسفور والبوتاسيوم على ثلاثة عينات من القصب

اخلاص محمد زين موسى محمد زين[1]

[1] كلية الزراعة، جامعة سنار، السودان.

HNSJ, 2022, 3(6); https://doi.org/10.53796/hnsj3614

تاريخ النشر: 2022/06/01م تاريخ القبول: 2022/05/17م

المستخلص

أجريت الدراسة بحقول سكر سنار خلال موسم 2014-2015 م لمعرفة تأثير إضافة سماد النتروجين والفسفور والبوتاسيوم على النمو وجودة القصب والسكر لثلاث عينات من القصب هي Co 527 و Co 997 و Co6808. أستعمل في التجربة نظام القطاعات العشوائية الكاملة بثلاثة مكررات. قياسات النمو الخضري تحت الدراسة هي عدد العقد، طول وعرض القصبة وكثافة النباتات. وقياسات جودة القصب هي نسبة الالياف وpol وBrix. أما قياسات جودة العصير هي الالياف والنقاوة و pol و Brix. أظهرت النتائج استجابة معنوية للعينات الثلاث للتسميد بالنتروجين والفسفور والبوتاسيوم مقارنة مع الشاهد. التسميد بالنتروجين والفسفور والبوتاسيوم أدى الي زيادة معنوية في عدد العقد وطول وعرض القصبة، بينما أدى التسميد بالفسفور الي زيادة معنوية في كثافة النباتات للعينات الثلاث. كانت استجابة العينة Co 6808 للتسميد بالنتروجين والفسفور والبوتاسيوم أفضل من العينات الأخرى. لم تتأثر نسبة pol و Brix في القصب بالتسميد، بينما زادت نسبة الالياف. لم تتأثر نسبة pol و Brix في عصير العينات الثلاث بالتسميد، بينما نقصت نسبة الالياف والنقاوة في عصير العينات الثلاث نقصاً معنوياً.

Introduction

Sugarcane is a tall growing monocotyledonous crop plant that is cultivated in tropical and subtropical regions of the world primarily for its ability to store high concentrations of sucrose or sugar in the internodes of the stem (Tai and Miller, 2001). According to FAO (2001) sugar cane is grown in not less than 105 countries and presently it covers a total acreage of about 19 million hectares for world production of approximately 1.3 million metric tons of cane and 17 million tons of sugar. The main Sugarcane producing areas in the world are India, Brazil, Cuba, Australia and Mexico (Clement, 1980). Sudan is one of the potential countries for growing sugar cane due to suitable soil, ample irrigation water, absence of serious disease and trained personal (Ahmed,1996).

Sugarcane is an important industrial and cash crop in many countries of the world, besides sugar production, sugarcane produces numerous valuable by-products like, alcohol which was used in pharmaceutical industry, ethanol used as fuel, bagasse used for paper and chip board manufacturing and press mud used as rich source of organic matter and nutrients for crop production (Kumar *et al*., 1996; Lingle *et al*., 2000).

Sugarcane was reported to rapidly deplete nutrients of soil, particularly nitrogen, phosphorus and potassium, so there is, need for addition of adequate amount of nitrogen, phosphorus and potassium fertilizers during the growth of sugarcane (Wood, 1990).

Nitrogen, the primary nutrient limiting sugarcane production is found in organic and inorganic form in the soil. Inorganic form of nitrogen occurs in oxide, nitrate and ammonium form. Most of the soil organic nitrogen exists in the form of organic matter (El Hefnawy, 1991). Nitrogen deficiency in sugarcane is expressed by many symptoms such as yellow-green color of leaves and retarded growth (Eltom, 1986). Nitrogen is usually absorbed by plants as nitrate, even though the fertilizers used may be NO^{-}_{3}, NH^{+}_{4} or organic in nature. The maximum uptake of nitrogen is during the early stages of growth. The two peaks of marked accumulation of nitrogen in leaves coincide with tillering and elongation phases (Clement, 1980). Application of nitrogen fertilizer significantly increased the number of tillers, stalk thickness, height and weight of sugar cane (Netsanet *et al.,* 2014), yield of sugar cane (Bokhtiar *et al*., 2008).

Phosphorus is a key nutrient required for higher and sustained productivity of sugar from sugar cane. Its influence on cane yield and juice quality has been well established and application of phosphorus has become an essential part of sugar cane fertilization program (Blackburn, 1984). Phosphorus help to build protein, it occurs in the nucleus of living cell and it thought to control most cell activities, it is essential for cell division which affect stalk and roots elongation (Clement,1980). Phosphorus is rapidly accumulated during the first six months, mainly in leaves; phosphorus also stimulates early root formation and development. Application of phosphorus fertilizer significantly increased the number of tillers, stalk height and yield of sugarcane (Ball-Coelho *et. al.,* 1993) and juice quality of sugarcane (Kumar and Verma, 1999)

Most of potassium needed by sugar cane will be taken up during shoot

population development, while maximum leaf area has been attained. Potassium absorbed as K^+ is the most abundant accumulating in the cell sap of sugar cane. The functions of potassium in sugar cane are many and have been extensively reviewed by Filho (1985) who reported that, the main role of potassium is an enzyme activator in plant metabolisms such as photosynthesis, protein synthesis, starch formation and translocation of proteins and sugar, and by Humbert (1968) stated that while the downwards movement of sugar from the leaves to storage tissues in the stalk proceeds as the rate of approximately 2.5 cm/ minute in a well potassium fertilized sugar cane, when a deficiency of potassium reduce the rate to below half that value. Application of potassium fertilizer increased cane yield (Parsad *et al*., 1996).

Although there is no consistent statistically significant interaction has been shown to exist between nitrogen, phosphorus and potassium fertilizers, a review of literature shows that inputs of nitrogen, phosphorus and potassium fertilizers must be balanced to optimize sugarcane production for high yield and good juice quality, in most sugarcane producing countries of the world the nitrogen, phosphorus and potassium fertilizers ratio is 2:1:3 or 2:1:2 or 3:1:5 (Milford *et. al.*, 2000).

The objective of this study is to know the effect of addition of nitrogen, phosphorus and potassium fertilizers on the growth of three varieties of sugarcane and quality of sugar.

Materials and Methods

A field experiment was conducted for one season (2014-2015) to study the effect of addition of nitrogen, phosphours and potassium fertilizers on the growth, yield and quality of three varieties of sugarcane. The experiment was conducted in Sinnar Sugar Factory Field. The experimental site lies within Latitude of 13.6° N, Longitude 33° E and Altitude 135 meter above sea level. The area lies in semi tropical savanna, the annual rain fall is 400-450 mm mostly falling from June to October, and annual temperature about 28˚C per day, maximum of 42˚C in May and minimum of 23˚C in January. The area of the experiment was prepared by ploughing, harrowing, leveling and ridging, the distance between rows was 1.5 m and the wide of row was 0.75 m. The rows were divided into 12 sections, each one contains four treatments, and the channels go through these sections. The treatment was laid out in a factorial randomized complete block design with four replicates. The treatments consisted of three varieties (Co 6806, Co 997 and Co 527) and four different fertilizers (control(0 Kg fertilizer),100 Kg N/ fed, 25 Kg P/ fed and 40 Kg K/fed).

A young plant age from 9-11 months was cut to a part which contain at least three internodes with active, healthy and not damage buds (this cutting called sets). Cane sets arrangement was sown as continuous double set arrangement along with at the bottom of the ridges in the experimental units, this method was used to avoid replanting, frequently irrigation was carried out after burring cane sets with soil manually using hand hoe. Gesapax and Gesaprium were used at rate of 2.4: 2.4 Kg /ha. Application of herbicide was done before the second irrigation.

The fertilizers 0 Kg fertilizer (control), 100 Kg N/ fed, 25 Kg P/fed and 40 Kg K/fed were added to Co 6896, Co 997 and Co 527 after 45 days from planting. Ten millable stalks were randomly cut and collected from the inner two rows of each plot to

measure the mean of internodes number, stalk height, stem diameter, plant density, and weight of cane. When the cane was 12 months old, ten millable stalks were selected at random from the sampling area in each plot. A sample representing the ten stalks was taken and its weight (kg) was recorded. The juice was extracted with a 3-roller mill, weighted (kg) and analyzed for Brix % of cane and juice (total soluble solids in the juice), Pol % of cane and juice, Fibre % of cane and juice and Purity % of juice were determined.

Results and Discussions

Application of nitrogen, phosphorus and potassium fertilizers significantly ($p \leq 0.05$) increased the number of internodes, the stalk height, stem diameter, plant density and weight of cane of the three sugar cane varieties (Co 527, Co 997 and Co 6808) compared with the control. Potassium fertilizer was more significantly effective on the three varieties than the two other fertilizers. The response of the variety Co 6808 to the three fertilizers was significantly higher than the two other varieties (Table 1, 2, 3, 4 and 5). Eltom (1986), Gawander *et al*. (2004) and Richard (2007) reported that application of nitrogen fertilizer significantly increased internodes number, stalk height, stem diameter, plant density and yield of sugar cane. Kummar and Verma (1999) reported that application of phosphorous fertilizers significantly increased the growth and yield of sugar cane. Khosa (2002) reported that application of potassium fertilizer significantly increased internodes number, stalk height, stem diameter, plant density and yield of sugar cane.

Purity% of juice significantly decreased by nitrogen, phosphorous and potassium application, the best purity% obtained by Co 527 variety (Table5).

Pol. % and Brix% of cane and of juice of the three varieties (Co 527, Co 997 and Co 6808) not affected by nitrogen, phosphorous and potassium application, where cane fiber % significantly increased by phosphorous application, and juice fiber% significantly decreased by potassium application (Table 6, 7 and 8).

Gawander *et al*. (2002) found that sucrose content of sugar cane significantly increased by application of nitrogen fertilizer. Kumar *et al*. (1996) found that application of phosphorous fertilizer significantly increased the juice quality of sugar cane. Khosan (2002) reported that application of potassium fertilizer significantly promotes the quality of cane.

The three quality results of this study were not in line with the quality results of above researchers, and these may be due to the different environmental conditions.

Table 1: Effect of nitrogen, phosphorus and potassium fertilizers on internodes number of three sugar cane varieties

Fertilizer	Month											
	7				8				9			
	varieties				varieties				varieties			
	Co527	Co997	Co6808	Mean	Co527	Co997	Co6808	Mean	*Co527*	Co997	Co6808	Mean
Control	15.67^{e}	19.33^{c}	20.67^{bc}	18.56^{b}	17.67^{e}	20.67^{cd}	21.00^{c}	19.78^{b}	21.33^{d}	22.00^{cd}	22.33^{cd}	21.89^{b}
100KgN/ha	16.67^{de}	20.67^{bc}	20.00^{bc}	19.11^{ab}	18.67^{de}	22.00^{bc}	22.00^{bc}	20.89^{b}	22.33^{cd}	23.67^{bc}	23.67^{bc}	23.22^{ab}
25Kg P/ha	17.33^{d}	21.00^{b}	21.00^{b}	19.11^{ab}	19.00^{de}	22.33^{b}	22.33^{b}	21.22^{b}	22.00^{cd}	24.00^{b}	24.00^{b}	23.33^{ab}
40 Kg K/ha	17.00^{de}	22.33^{ab}	22.67^{a}	20.67^{a}	19.33^{d}	23.00^{ab}	24.00^{a}	22.11^{a}	22.67^{c}	25.00^{ab}	25.33^{a}	24.33^{a}
Mean	16.67^{b}	20.83^{ab}	21.09^{a}		18.67^{b}	22.00^{ab}	22.33^{a}		22.08^{b}	23.67^{ab}	23.88^{a}	
LSD	1.66				1.30				1.30			

Table 2: Effect of nitrogen, phosphorus and potassium fertilizers on stalk heights (cm) of three sugar cane varieties

Fertilizer	Month											
	7				8				9			
	varieties				varieties				varieties			
	Co527	Co997	Co6808	Mean	Co527	Co997	Co6808	Mean	*Co527*	Co997	Co6808	Mean
Control	329.0^{e}	375.3^{ab}	342.0^{d}	348.7^{b}	335.6^{e}	380.o^{ab}	347.0^{d}	354.2^{b}	342.00^{e}	384.00^{b}	358.33^{d}	361.44^{b}
100KgN/ha	346.6^{cd}	378.6^{ab}	356.6^{c}	360.6^{b}	352.6^{cd}	384.3^{ab}	360.3^{c}	365.7^{b}	357.67^{de}	390.00^{a} b	366.00^{cd}	371.22^{b}
25Kg P/ha	352.6^{cd}	379.0^{ab}	366.6^{bc}	366.1^{ab}	356.3^{cd}	382.6^{ab}	368.6^{bc}	369.2^{ab}	363.33^{cd}	390.00^{a} b	373.33^{c}	375.55^{ab}
40 Kg K/ha	361.6^{bc}	382.3^{a}	369.3^{b}	371.1^{a}	375.3^{b}	387.3^{a}	375.0^{bc}	379.2^{a}	379.00^{bc}	394.33^{a}	380.67^{bc}	384.67^{a}
Mean	347.5^{c}	378.8^{a}	358.6^{b}		355.0^{b}	383.5^{a}	362.^{b}		360.50^{b}	389.58^{a}	369.58^{b}	
LSD	10.50				11.2				10.22			

Table 3: Effect of nitrogen, phosphorus and potassium fertilizers on stem diameter (cm) of three sugar cane varieties

Fertilizer	Month											
	7				8				9			
	varieties				varieties				varieties			
	Co527	Co997	Co6808	Mean	Co527	Co997	Co6808	Mean	*Co527*	Co997	Co6808	Mean
Control	1.70^{c}	1.70^{c}	1.83^{bc}	1.74^{b}	1.77^{d}	1.77^{d}	2.00^{cc}	1.85^{b}	2.00^{e}	2.10^{d}	2.20^{cd}	2.10^{b}
100KgN/ha	1.90^{b}	1.70^{c}	2.10^{ab}	1.90^{ab}	2.07^{bc}	1.90^{c}	2.30^{a}	2.09^{ab}	2.17^{cd}	2.20^{cd}	2.40^{ab}	2.26^{ab}
25Kg P/ha	2.10^{ab}	1.77^{bc}	1.90^{b}	1.92^{ab}	2.23^{ab}	2.00^{bc}	2.13^{b}	2.12^{a}	2.33^{b}	2.17^{cd}	2.30^{bc}	2.27^{ab}
40 Kg K/ha	1.90^{b}	2.13^{a}	1.87^{bc}	1.97^{a}	2.10^{bc}	2.27^{ab}	2.10^{bc}	2.16^{a}	2.17^{cd}	2.43^{a}	2.23^{c}	2.28^{a}
Mean	1.90^{a}	1.83^{a}	1.93^{a}		2.04^{ab}	1.99^{b}	2.13^{a}		2.17^{b}	2.23^{ab}	2.28^{a}	
LSD	0.16				0.13				0.10			

Table 4: Effect of nitrogen, phosphorus and potassium fertilizers on plant density of three sugar cane varieties

Fertilizer	Month											
	7				8				9			
	varieties				varieties				varieties			
	Co527	Co997	Co6808	Mean	Co527	Co997	Co6808	Mean	*Co527*	Co997	Co6808	Mean
Control	125.6^{cd}	114.3^{d}	135.6^{bc}	125.2^{b}	133.0^{c}	134.6^{c}	147.6^{bc}	138.4^{b}	149.0^{bc}	144.3^{c}	159.6^{bc}	151.0^{ab}
100KgN/ha	138.6^{bc}	128.0^{c}	150.3^{ab}	139.0^{b}	139.0^{c}	139.0^{c}	157.0^{ab}	145.0^{b}	157.6^{bc}	152.3^{bc}	169.3^{ab}	159.7^{b}
25Kg P/ha	152.3^{ab}	154.3^{a}	141.0^{b}	149.2^{a}	163.6^{ab}	171.3^{a}	153.6^{bc}	162.8^{a}	173.3^{ab}	178.3^{a}	162.0^{b}	171.2^{a}
40 Kg K/ha	133.33^{bc}	150.6^{ab}	146.3^{ab}	143.4^{ab}	152.6^{bc}	165.3^{ab}	155.3^{b}	157.7^{ab}	168.0^{ab}	178.3^{a}	165.6^{ab}	170.6^{ab}
Mean	137.5^{a}	136.8^{a}	143.3^{a}		147.0^{a}	152.5^{a}	153.4^{a}		162.0^{a}	163.3^{a}	164.0^{a}	
LSD	11.1				15.1				13.91			

Table 5: Effect of nitrogen, phosphorus and potassium fertilizers on weight of ten stalks cane of three sugar cane varieties

Fertilizer	varieties			
	Co 527	Co 997	Co 6808	Mean
Control	93.00^{g}	95.00^{f}	90.00^{h}	92.67^{d}
100 kg N/ha	108.00^{c}	103.00^{d}	98.00^{ef}	103.00^{b}
25 kg P /ha	119.00^{a}	113.00^{b}	103.00^{d}	111.67^{a}
40 kg K /ha	99.00^{e}	98.00^{ed}	94.00^{fg}	97.00^{c}
Mean	104.75^{a}	102.25^{b}	96.25^{c}	
LSD		2.00		

Table 6: Effect of nitrogen, phosphorus and potassium fertilizers on purity % Juice of three sugar cane varieties

Fertilizer	varieties			
	Co 527	Co 997	Co 6808	Mean
Control	95.48^{b}	94.64^{c}	97.03^{a}	95.72^{a}
100 kg N/ha	94.84^{bc}	93.79^{d}	94.96^{bc}	94.53^{b}
25 kg P /ha	96.55^{bc}	92.68^{e}	93.53^{de}	94.25^{b}
40 kg K /ha	95.29^{bc}	94.29^{cd}	94.21^{cd}	94.60^{b}
Mean	95.54^{a}	93.85^{b}	94.93^{ab}	
LSD		0.79		

Table 7: Effect of nitrogen, phosphorus and potassium fertilizers on pol %, fiber %and Brix % cane of three sugar cane varieties

Fertilizer	Pol %				Fiber %				Brix %			
	varieties				varieties				varieties			
	Co527	Co997	Co6808	Mean	Co527	Co997	Co6808	Mean	*Co527*	Co997	Co6808	Mean
Control	14.0^{cd}	13.4^{d}	15.0^{ab}	14.1^{a}	16.8^{de}	16.73^{e}	16.70^{e}	16.74^{b}	15.0^{bc}	14.6^{c}	15.8^{ab}	15.1^{a}
100KgN/ha	14.1^{cd}	14.0^{cd}	15.0^{a}	14.4^{a}	17.3^{b}	16.8^{d}	16.9^{cd}	17.0^{ab}	15.2^{bc}	15.3^{bc}	16.2^{ab}	15.6^{a}
25Kg P/ha	13.3^{d}	14.6^{b}	14.8^{ab}	14.2^{a}	17.4^{a}	17.1^{c}	17.2^{bc}	17.2^{a}	14.2^{c}	16.1^{ab}	16.8^{a}	15.5^{a}
40 Kg K/ha	14.0^{cd}	14.1^{cd}	14.2^{c}	14.1^{a}	17.4^{ab}	16.9^{cd}	17.1^{c}	17.1^{ab}	15.1^{bc}	15.4^{bc}	15.5^{b}	15.3^{a}
Mean	13.8^{b}	14.0^{b}	14.7^{a}		17.2^{a}	16.9^{b}	17.0^{ab}		14.9^{b}	15.2^{b}	15.9^{a}	
LSD	0.3				0.2				0.5			

Table 8: Effect of nitrogen, phosphorus and potassium fertilizers on pol %, fiber %and Brix % juice of three sugar cane varieties

Fertilizer	Pol %				Fiber %				Brix %			
	varieties				varieties				varieties			
	Co527	Co997	Co6808	Mean	Co527	Co997	Co6808	Mean	*Co527*	Co997	Co6808	Mean
Control	20.0^{cd}	19.5^{d}	21.5^{a}	20.3^{a}	17.30^{cd}	18.50^{a}	17.60^{c}	17.80^{a}	21.00^{de}	20.70^{de}	22.20^{b}	21.30^{a}
100KgN/ha	20.3^{c}	20.1^{cd}	21.4^{ab}	20.6^{a}	18.00^{b}	17.40^{cd}	17.20^{d}	17.53^{ab}	21.15^{cd}	21.43^{cd}	22.60^{ab}	21.73^{a}
25Kg P/ha	19.3^{d}	20.9^{b}	21.2^{ab}	20.4^{a}	18.00^{b}	17.30^{cd}	17.40^{cd}	17.57^{ab}	20.00^{e}	22.55^{ab}	22.73^{a}	21.76^{a}
40 Kg K/ha	20.0^{cd}	20.3^{cd}	20.3^{cd}	20.2^{a}	17.20^{d}	17.50^{cd}	17.20^{d}	17.30^{b}	21.04^{d}	21.53^{cd}	21.60^{c}	21.39^{a}
Mean	19.9^{b}	20.2^{b}	21.1^{a}		17.63^{a}	17.66^{a}	17.35^{a}		20.88^{c}	21.55^{b}	22.28^{a}	
LSD	0.4				0.33				0.53			

References:

Ahmed, M.O. (1996). Studies on quality of sugar cane in the Sudan. M. Sc. Thesis, University of Khartoum, Sudan.

Ball-Coelho, B; H Tiessen; JWB Stewart; IH Salcedo & EVSB Sampaio. 1993. Residue management effects on sugarcane yield and soil properties in Northeastern Brazil. *Agron. J.* 85: 1004-1008.

Blackburn, F. (1984). Sugarcane (Tropical Agriculture Series). Longman House Burnt Mill, England 389 PP.

Bokhtiar, S.M; Paul, G. C.; Alam, K. M. 2008. Effect of organic and inorganic fertilizer on growth, yield and juice quality and residual effects on ratton crops of sugarcane. Journal of Plant Nutrition, 31 (10): 1832-1843.

Clement,R. (1980). Sugar cane crop logging and crop control principles and practices, The University press of Hawii, Honolulu.

El Hefnawy, N. N. (1991). Effects of different nitrogen fertilization level and plant Density. Agric. Research **16**:229-237.

El tom , Y. (1986). Influence of nitrogen on sugar cane. Faculty of Agriculture, University of Khartoum, Sudan.

F. A. O. (2001). Food and Agriculture Organization of the United Nation, Rome

Filho,J. O. 1985. Potassium nutrition of sugarcane. In: Potassiumin agriculture. (Ed. Munson, R. D.). American Society of Agronomy. Crop Science Society of America. Soil Scince Society of America. Madison. Pp 1045-1062.

Gawander, J.S., P. Gangaiya and R.J. Morrison, 2004. Potassium responses and budgets in the growth of sugarcane in Fijii. Sugar Cane International 22: 3-8.

Humbert, R. (1968). The growing of sugar cane. Elsevier pub. Co. Amestrdam, Netherlands. pp: 131-145.

Khosa, T. M. (2002). Effect of different levels and sources of potassium on growth,

yield and quality of sugarcane. Better Crops International, Vol. 16, No. 1, pp 14-15.

Kumar, M.D., K. S. Channabasappa and S.G. Patil. 1996. Effect of integrated application of pressmud and paddy husk with fertilizer on yield and quality of sugarcane (Saccharum officinarum L.). Ind. J. Agron., 41:301-305.

Kumar,V. and Verma, K.(1999). Influence phosphorus yield and juice quality on sugarcane growth on phosphorus deficient soil. India sugar .49:579-588.

Lingle, S.E., R.P. Wiedenfeld and J.E. Irvine. 2000. Sugarcane response to saline irrigation water. J. Plant Nutrition, 23:469-486.

Milford, G.F. J.;Armstrong, M. J.; Jarvis, P. J.; Houghton, B. J.; Bellett- Travers, D. M.; Jones, J. and Leigh, R. A. 2000.Effects of potassium fertilizer on the yield, quality and potassium offtake of sugar beet crops grown on soils of different potassium status. Journal of Agricultural Science 135: 1-10.

Netsanet A, Getaneh A, Mekuanent Y, Mengistu L, Bikila M, Hagos H. 2014. Effect of different planting methods of soybean in an intercropping with sugarcane at Wonji-Shoa sugar estate. Journal of Agriculture and Natural Resources Sciences 1: 180–185.

Prasad, R.; Prasad, U. S. and Sakal R. 1996. Effect of potassium and sulfur on yield and quality of sugar cane grown in clacreous soils. Journal of Potassium Researc 12: 29-38.

Richard, E. J. (2007). The effect of nitrogen on sugarcane production,Louisiana State University.

Tai, P. Y. P. and Miller, J.D. (2001). Acores collection for *Saccharum spotaneum* L. Crops science society of America **41**: 879-885.

Wood, R.A. (1990). The roles of nitrogen, phosphorus and potassium in the production of sugar cane in South Africa. Fertilizer Research 26:87-98.