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Effect of Filter Cake and Ammonium Sulphate Nitrate (ASN) on Yield of Sugarcane at Metahara Sugar Estate

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ABSTRACT

A study was conducted at Metahara sugar estate, Ethiopia, to determine the optimum rates of filter cake and nitrogen fertilizer for sugarcane production. The experiment was laid out in randomized complete block design with three replications. Five levels of filter cake (0, 30, 60, 90, 120t ha^{-1}) with four levels of N (0, 52, 78, 104 kg ha^{-1} as ASN) were studied as treatment combinations. Filter cake was applied after land leveling operation (ie, before furrowing) and nitrogen was applied at 2.5 months after planting. The results indicated that filter cake and nitrogen treatment combinations had highly significant ($P \leq 0.01$) effect both on cane and sugar yields. Hence, all filter cake rates applied with 78kg N ha^{-1} and 104kg N ha^{-1} resulted in high cane and sugar yields per unit area compared to the yield due to conventional fertilizer rate (104kg N ha^{-1}). Cost-benefit analysis of adjusted sugar yield also revealed that 30t filter cake ha^{-1} and 60 filter cake t ha^{-1} each rate applied with 78kg N ha^{-1} were found to be economically viable treatment combinations. Moreover, application of filter cake resulted in improved fertility status of soils especially that of phosphorous availability. Thus, based on sugar yield response, cost benefit analysis result and residual effect of filter cake on soil properties, 30t filter cake ha^{-1} was recommended to be applied with 78kg nitrogen ha^{-1} as ASN regardless of soil types to ensure sustainable sugarcane production.

Keywords: Filter cake, nitrogen fertilizer, sugar yield, cost-benefit analysis.

INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important industrial crop cultivated in different parts of the world mainly for plantation white sugar. In Ethiopia, the crop is cultivated at Wonji-Shoa, Metahar and Finchaa sugar estates with a potential of expansion to new sites.

The available literature (Kakde, 1985; Faucconnier, 1993; Sundara, 2000) indicated that sugarcane is a heavy feeder of nutrients. Hence to meet nutrient requirements of the crop and achieve higher yields, mineral fertilizers are commonly applied in sugarcane production. Use of mineral fertilizers alone as a source of nutrients, however, could not ensure sustainable productivity of soils and achieving higher yields. Especially in soils which are low organic matter contents, fertilizers cannot have their full beneficial effects on crop yields (Incle *et al*., 1999; FAO, 2000; Gustafson, 2007). Thus combined use of organic materials and mineral fertilizers can be an important option if productivity of soils is to be maintained at a desirable level. Organic additions are known to improve both physical properties and fertility status of soils (Ahenkorah *et al.*, 1993; Lal and Nor, 1994; Shakweer *et al*., 1998; Sundara, 2000; Kaur *et al*., 2007; Tangkoonboribun *et al*., 2007). Studies carried out in Ethiopia (ie, at Holeta, Bako and Awassa) also indicated that combined use of organic materials and mineral fertilizers resulted in increased grain yield of cereals (Bekele, 1996). Different reports (Korndofer and Anderson, 1997; Morris *et al*., 2007) also indicated that when filter cake was used with mineral fertilizers it improved sugar yield per unit area compared to sugar yield obtained by using mineral fertilizers alone.

According to the available literature (Chang Yen *et al.*, 1983; Blackburn, 1984; Kakde, 1985; Facunnier, 1993; Korndorfer and Anderson, 1997), filter cake is known to be a good source of organic matter and plant nutrients mainly phosphorous, nitrogen, calcium, sulphur and micronutrients. Because of its high organic matter content, filter cake has positive effect on soil physical properties (aeration and drainage on clay soils, and moisture and nutrient retention capacity on sandy soils) (Sundrara, 2000). From environmental point of view, it is known to have no side effects when applied to farm lands especially after two to three months of curing (Korndofer and Anderson, 1997; Sundara, 2000). However, according to the same authors, when filter cake was applied at higher doses it affected permeability and infiltration rate of the soil.

At Metahara, filter cake (by-product of sugar processing) is produced each year at large quantities. However, such important by-product has not been used for agricultural purpose by the sugar estate. At present, however, since cost of mineral fertilizers is increasing at an alarming rate on one hand, and there is high need to improve productivity of sugrarcane fields on the other, effective use of such locally available and valuable by-product for sugarcane production became critically important.

Therefore, this study was, conducted with the major objective to determine optimum rates of filter cake and nitrogen fertilizer for sugarcane production.

MATERIALS AND METHODS

Site Description

The study was conducted at Metahara Sugar Estate which is located in the upper Awash River basin, at about 200km east of Addis Ababa, capital city of Ethiopia. The estate lies within the general boundaries of $8^{\circ}51'$N latitude and $39^{\circ}52'$E longitude and it is situated at elevation of 950m above sea level. The area receives about 545mm rainfall annually and mean maximum and minimum temperatures are about 33.9°C and 17.4°C, respectively. Soils of the sugar estate are grouped into two major soil units; Luvisol and clay soil (Booker Tate 2009). And the estate uses furrow irrigation system for sugarcane production.

Treatments and design

The experiment was conducted on two major soil types (Luvisol and Clay). Filter cake rates were 0, 30, 60, 90, and 120t ha^{-1} while nitrogen rates include 0, 52, 78, and 104kg ha^{-1}. The source of nitrogen was ASN. The experiment was laid out in randomized complete block design (RCBD) with three replications in factorial arrangement. The plot size used was 52.2 m^2 (6 furrows of 6 m long and 1.45 m wide).

Filter cake rates (air dried) were applied manually in the furrows and at ridge sides immediately after furrowing. The treatments were incorporated with soil manually using forks. To prevent mixing of treatments between plots during pre-planting and early irrigations after planting, each plot was irrigated by closing furrow ends. Planting was executed using healthy setts of test variety (NCO334). Immediately after planting, the setts were covered with soil and each plot was irrigated lightly. After 3 to 4 irrigations, furrow ends of the plots were opened and the standard irrigation practice continued until harvesting. Nitrogen treatments were applied 2.5 months after planting. Then, the experimental fields were managed as per the field operation standards followed by the Estate.

Data Collection

Collection of Soil Samples

Composite soil samples were taken at harvest from control plots and those plots receiving treatments. The samples were analyzed for major physicochemical properties ($EC_{1:2.5}$, $pH_{1:2.5}$, organic carbon, available phosphorous, total nitrogen, and texture) following standard analytical procedures (Sahlemedhin and Taye, 2000). Air dried filter cake samples were also taken and analyzed for pH $_{(1:2.5)}$, EC $_{(1:2.5)}$, available phosphorous, available potassium, total nitrogen and organic carbon following standard procedures (Abejehu, 2001).

Collection of Crop Data

Among crop data cane and sugar yields were determined at harvest. Cane yield of the middle four furrows of each plot was measured was measured using tractor- mounted crane scale. Sucrose percent cane was determined after extracting the juice with a sample mill following the procedure of Mathur (1981). Sugar yield was determined by multiplying cane yield per hectare by sucrose percent cane.

Finally cane and sugar yields data were subjected to analysis of variance using the MSTAT computer programme. Mean yields (treatment means) of the interaction effects and the main effects were computed using Duncan’s Multiple Range Test (DMRT) and Least Significant Difference test (LSD), respectively.

Cost Benefit Analysis

The values of cost benefit ratio and net return were determined by considering the following conditions: sugar price (4000.00 birr t^{-1} at the factory gate, estimated cost of Urea (6000 birr t^{-1}), cost of production (2816.7 birr t^{-1} of sugar; which includes cost of fertilizer for the recommended rate, cost of herbicides, cost of labor, etc), cost of filter cake application to cane fields within the average distance of about 8.5km from the Factory site (which also includes loading and transportation costs) (birr ha^{-1}): 926.97, 1137.34, 1350.10, and 1560.92; for filter cake rates 30, 60, 90, and 120t ha^{-1}, respectively.

For the purpose of cost benefit analysis, experimental sugar yield was adjusted down by 15% to reflect commercial sugar yield under the actual plantations’ management practices.

RESULTS AND DISCUSSION

Chemical Composition of Filter Cake

Analytical result of filter cake from Metahara sugar factory is presented in Table 1. pH value of composite air dried filter cake sample (after 2 to 3 months of curing) was near neutrality and its salt content was low.

Table 1: Chemical composition of composite filter cake at Metahara sugar estate

Parameters	Analytical result
pH(1:2.5)	7.6
EC (1:2.5) (dS/m)	1.31
Total nitrogen (%)	1.12
Available phosphorous (%)	0.43
Organic carbon (%)	25.32

In view of its nutrient content, it was found to be rich in phosphorous and total nitrogen contents (Table 1). The analytical result indicates that a ton of air dried filter cake can supply about 11.2kg N ha^{-1} and 4.3kg P (9.85 kg P_2O_5) to the soil. The result is in agreement with the findings of Korndorfer *et al*., (1997) in Brazil who reported that a ton of air dried filter cake contained on the average 12kg N ha^{-1}and 8.7kg P ha^{-1} (19.92 kg P_2O_5 ha^{-1}). The samples were also high in organic carbon content, and this implies that it can be an important source of organic matter when applied to the soil, which in turn, has a positive effect in improving both soil physical properties and chemical properties.

Effects of Filter Cake on Major Soil Chemical Properties

Analytical results of soil samples taken from experimental fields immediately after harvesting of plant cane are indicated in Table 2.

The results showed that application of filter cake had no remarkable effect on pH and EC (salt content) of soils of sugarcane plantation. However, it highly improved available phosphorous status and organic carbon content of the soils (Table 2).

High values of organic carbon in both soil types (light soil and clay soil) recorded at harvest and analytical results of filter cake (Table 2) indicated that filter cake could be an important source of organic matter to the soil, which in turn, plays a key role in maintaining nutrient supply and retention properties of soils and improves soil structure. Similarly, the beneficial effects of filter cake in improving soil quality had been reported by different authors (Fauconnier, 1993; Sundara, 2000; Moris *et al*., 2007). It was also noted that in plots receiving no filter cake, status of available phosphorous and total nitrogen in the soil remained low in both soil types (Table 2).

Table 2: Residual effect of filter cake on major soil chemical properties

Filter cake (t ha^{-1})	Major soil chemical properties at harvest				
	pH (H2O) (1:2.5)	EC (1:2.5) (dS/m)	Total N (%)	Available P (ppm)	Organic C (%)
Light soil (Luvisol)					
0	8.3	0.21	0.10	9.60	1.10
30	8.3	0.20	0.14	57.00	2.97
60	8.3	0.21	0.16	76.85	3.07
90	8.2	0.20	0.14	88.60	3.13
120	8.3	0.19	0.16	89.40	3.17
Heavy soil (Clay soil)					
0	8.2	0.29	0.12	7.81	1.47
30	8.1	0.33	0.14	41.65	3.66
60	8.2	0.34	0.16	69.79	4.06
90	8.3	0.29	0.14	75.90	4.24
120	8.2	0.38	0.16	87.35	4.51

Effect of Filter Cake on Cane and Sugar Yields

ANOVA of cane and sugar yields indicated that the interaction effect of filter cake with nitrogen was highly significant ($P \leq 0.01$) for cane yield and significant ($P \leq 0.05$) for sugar yield on light soil and highly significant ($P \leq 0.01$) both for cane yield and sugar yield ($P \leq 0.01$) on heavy soil (Appendix Table 1). The main effect of filter cake was highly significant ($P \leq 0.01$) both for cane yield and sugar yield on both soil types and while the main effect of nitrogen was not significant ($P \leq 0.05$) both for cane and sugar yields on both soil types.

On both soil types, high cane yield per unit area was obtained at all levels of filter cake applied with nitrogen fertilizer (ASN) compared to the conventional practice (Table 3).

On both soil types, combined application of 60t filter cake ha^{-1} with 78kg N ha^{-1} resulted in highest cane tonnage (Table 3). Application of 30t filter cake ha^{-1} with the same rate of nitrogen also gave statistically similar result. However, Cane yield due to nitrogen fertilizer applied alone was inferior regardless of the dose and soil types compared to yield due to combined applications.

Table 3: Cane yield (t ha^{-1}) as affected by filter cake and nitrogen application on light and heavy soils

Filter cake rate (t ha^{-1})	Nitrogen (kg ha^{-1})			
	0	**52**	**78**	**104**
Light soil (Luvisol)				
0	206.5^{e}	225.7^{de}	243.7^{bd}	243.7^{bd}
30	234.8^{cd}	259.9^{ad}	268.5^{ab}	268.5^{a}b
60	250.3^{bd}	262.7^{ad}	298.3^{a}	298.3^{a}
90	260.8^{ad}	265.3^{ad}	296.0^{a}	296.0^{a}
120	258.9^{ad}	270.0^{ac}	297.0^{a}	297.0^{a}
Heavy soil (Clay soil)				
0	267.4f	281.7ef	2930df	297.3ce
30	291.6df	302.9be	325.4ab	322.4ac
60	294.5de	310.6ad	338.5a	328.0ab
90	303.7be	315.4ad	327.9ab	325.8ab
120	303.8be	313.0ad	328.0a	327.3ab

Means with the same letter for each parameter at each soil type are not significantly different at $p \leq 0.05$ from each other according to DMRT.

Like cane yield, no significant difference was observed in sugar yield obtained due to combined applications of filter cake and nitrogen suggesting that both materials have complementary effect in improving growth and yield of sugarcane. Accordingly, about 12.6 % (3.9t ha^{-1}) and 18.1 % (5.6 t ha^{-1}) sugar yield increments were obtained on light soil over the conventional nitrogen rate due to combined application of 30t filter cake ha^{-1} with 78 kg N ha^{-1}, and 60t filter cake ha^{-1} with 78 kg N ha^{-1}, respectively (Table 4). On heavy soil, the relative sugar yield advantage due to combined application of 30t filter cake ha-1 with 78kg N ha^{-1} and 60t filter cake ha-1 with 78kg N ha^{-1} was about 8.6 % (3.3t ha^{-1}) and 9.4 % (3.6t ha^{-1}) over the conventional nitrogen rate, respectively. In line with this, studies carried out using filter cake and mineral fertilizers elsewhere indicated that application of filter cake increased both cane and sugar yields by 26 % compared to mineral fertilizer treatment (Mories *et al.*, 2007). Kaur *et al.*, (2004) also stressed the importance of nutrient recycling by using organic materials with mineral fertilizers together.

As indicated in Table 4, application of nitrogen without filter cake on both soil types resulted in low sugar tonnage at all levels compared to combined applications of both materials. Moreover, absence of statistically significant difference among all nitrogen rates on cane and sugar yields indicates that application of nitrogen at 104kg ha^{-1} at Metahara cane plantation is not economical.

Table 4: Sugar yield (t ha^{-1}) as affected by filter cake and nitrogen application on Luvisol and Clay soil types

Filter Cake (t ha^{-1})	Nitrogen (kg ha^{-1})			
	0	52	78	104
Luvisol				
0	26.0^{f}	27.2^{ef}	30.8^{bf}	30.9^{bf}
30	27.5^{ef}	31.4^{ae}	34.8^{ac}	34.0^{ac}
60	28.8^{df}	31.9^{ae}	36.5^{a}	35.5^{ab}
90	30.8^{bf}	33.4^{ad}	36.2^{a}	34.0^{ac}
120	30.0^{cf}	32.8^{ad}	36.4^{a}	34.1^{ac}
Clay soil				
0	33.8^{f}	36.0^{ef}	37.0^{de}	38.2^{be}
30	36.3^{ef}	39.1^{ad}	41.5^{a}	40.0^{ad}
60	37.5^{ce}	39.8^{ad}	41.8^{a}	40.2^{ac}
90	37.4^{ce}	39.7^{ad}	40.9^{ab}	39.8^{ad}
120	38.4^{be}	39.4^{ad}	40.8^{ab}	40.9^{ab}

Means followed by the same letter at each soil type are not significantly different at $p \leq 0.05$ according to DMRT.

Cost-benefit Analysis

Cost-benefit analysis result of this study revealed that on both soil types, high values of net return at the selling price of 4000 Birr t^{-1} of sugar were obtained at 30 t ha^{-1}, 60t ha^{-1}, 90t $ha^{-1}$and 120t ha^{-1} filter cake rates each applied with 78kg N ha^{-1} (Table 5). On the other hand, economically viable filter cake-mineral fertilizer treatments combinations on both soil types were found to be 30t filter cake ha^{-1} and 60t filter cake ha^{-1} each applied with 78 kg N ha^{-1}, and 60t filter cake ha^{-1} applied without nitrogen. Moreover, on light soil, 78kg N ha^{-1} applied without filter cake was found to be economically viable treatment.

Table 5: Net return (birr ha^{-1}) and cost benefit analysis result of filter cake and nitrogen experiment at Metahara sugarcane plantation

Filter cake (t ha^{-1}) + N (kg ha^{-1})	Luvisol		Clay soil	
	NR	CBR	NR	CBR
O + 0	-	-	-	-
0 + 52	349.70	1:1.10	1709.40	1:1.27
0 + 78	4059.77	1:1.33	2292.16	1:1.26
0 + 104	3690.74	1:1.28	3146.86	1:1.26
30 + 0	1928.84	1:1.30	2064.37	1:1.31
30+52	4317.92	1:1.31	4181.68	1:1.30
30+78	7755.78	1:1.35	6532.65	1:1.33
30+104	3298.99	1:1.30	4259.44	1:1.25
60+0	2925.94	1:1.39	3213.70	1:1.34
60+52	4787.13	1:1.31	4923.10	1:1.31
60+78	9448.99	1:1.36	6729.59	1:1.32
60+104	7856.23	1:1.32	4321.01	1:1.25
90+0	4224.67	1:1.35	2861.97	1:1.30
90+52	6026.01	1:1.31	4438.40	1:1.29
90+78	8784.29	1:1.34	5629.07	1:1.30
90+104	5695.86	1:1.26	3564.37	1:1.21
120 + 0	3334.00	1:1.30	3741.91	1:1.32
120 + 52	5315.34	1:1.30	2945.64	1:1.18
120 + 78	8889.44	1:1.34	45477.28	1:1.24
120 + 104	5801.	1:1.27	4713.25	1:1.24

Note: FC=Filter Cake, N=Nitrogen, NR=Net Return, CBR=Cost Benefit Ratio

In general, the present findings revealed that combined use of filter cake and mineral fertilizer was advantageous compared to using mineral fertilizer alone to ensure improved productivity of sugar cane per unit area and get better net return. The available literatures also indicate that use of filter cake with mineral fertilizers had beneficial effect in increasing sugar yield compared to mineral fertilization alone (Korndorffer and Anderson, 1997; Sundara, 2000; Moris *et al*., 2007; Tangkoonboribun *et al*., 2007).

CONCLUSION

Findings of this study indicated that higher cane and sugar yields from plant cane experiment were obtained due to combined application of air dried filter cake with ASN fertilizer at all filter cake rates applied in combination with different levels of nitrogen. In addition, as evident from soil analytical results after harvesting of plant cane, application of filter cake highly improved nutrient availability (especially that of phosphorous) in the root zone of soils. Organic carbon (i.e., organic matter) content of soils was also highly improved; hence, ensuring sustainable productivity of sugarcane fields which are under intensive sugarcane production

Cost-benefit analysis result also revealed that 30t filter cake ha^{-1} and 60t filter cake ha^{-1} each rate applied with 78kg N ha^{-1} and 60t filter cake ha^{-1} applied without nitrogen were found to be economically viable regardless of soil types.

Therefore, based on the present finding (biological sugar yield and cost benefit analysis result), 30t filter cake ha^{-1} is recommended to be applied with 78kg N ha^{-1} (as ASN) at air dried condition regardless of soil types.

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REFERENCES

Abejehu, G. 2001. Laboratory procedures for determination of important constituents in organic wastes/materials: *Literature Review*. Ethiopian Sugar Industry Support Center Sh. Co., Research and Training services, Wonji, Ethiopia

Ahenkorah Y, E. Owusu-Bennoah, G.N.N. Dowuoana (eds.). 1993. Sustaining soil productivity in intensive African agriculture. *Seminar proceedings*, Acra, Gahana, 15-19 November 1993.

Bekele, T. 199). Utilization of organic residues in Ethiopia. A Review. In: Teshome Yizengaw, Eyasu Mekonnen, and Minesnot Behailu (eds). *Proceedings of the Third Conference of Ethiopian Society Soil Science* (ESSS), 162-168, February 28-29, 1996, Addis Ababa, Ethiopia.

Blackburn, F. 1984. *Sugarcane*. Tropical Agricultural Series, Longman Group, UK Ltd.

Chang-Yen, I., P.I. Bodoe, and R. Mohammed. 1983. Chemical analysis of seven nutrient elements in some sugarcane by-products. *Tropical Agriculture*. 60 (1): 41-45.

Facounnier, R. 1993. Sugarcane. The Tropical Agriculturalist. The MacMillan Press Ltd.

Food and Agriculture Organization (FAO). 2000. Fertilizers and their use. A pocket guide for extension officers. 4th edition, FAO, Rome, 2000.

Gustafson, A.F. 2007. Soils and soil management. Agrobios, India.

Inckel, M., P.D. Smet, T. Tersmette, and T. Veedkamp. 1999. Preparation and use of compost. Agrodok-series, No. 8, CTA, Netherlands.

Kakde, J.R. 1985. Sugarcane production. Metropolitan Book Co., Pvt. Ltd., India.

Kaur, K., K.K. Kapoor, and A.P. Gupta. 2004. Impact of organic manures with and without mineral fertilizers on soil chemical and biological properties under tropical conditions. *Journal of Plant Nutrition and Soil Science*. 117-122.

Korndorfer, G.H., and D.L. Anderson. 1997. Use and impact of sugar-alcoohol residues; vinase and filter cake on sugarcane production in Brazil. *SUGAR y AZUGAR*, pp: 26-35.

Matur, R.B.L. 1981. Handbook of cane sugar technology. Oxford and IBH, New Delhi.

Miller, R.W., and R.L. Donahue. 1997. Soils in our environment. 7th ed., Prentice House of India, New Delhi.

Moris, D.R., R.A. Gilbert, C.R. Rainbol, R.E. Perdomo, G. Powell, B. Eiland, and G. Montes. 2007. Sugarcane yields and soil chemical properties due to mill mud application to sandy soil. *Proceedings of International Society of Sugar Cane Technologists*. 26: 85-89.

Scholl, L.V. 1998. Soil fertility management. Agrodok-series No.2, CTA, The Netherlands.

Sertsu, S., and T. Bekele (eds.) (2000). *Procedures for soil and plant analysis.* Technical paper 74. National Soil Research Center, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.

Sundara, B. 2000. Sugarcane cultivation. Vikas Publishing House, Pvt. Ltd., India

Tangkoonboribun, R., S. Ruaysoongnern, P. Vityakon, B. Toomsan, and M.S. Rao. 2007. Effect of organic ameliorants to improve soils using sugarcane as a model. *Proceedings of International Society of Sugar Cane Technologists*. 26:107-112.

Appendix Table 1: ANOVA of cane and sugar yields of plant cane at Metahara Sugar Estate

Source of variation	Degree of freedom	Soil type			
		Light soil		Heavy soil	
		Cane	Sugar	Cane	Sugar
Filter cake (FC)	4	**	**	**	**
N (ASN)	3	ns	ns	ns	ns
FC x N (ASN)	12	**	*	**	**
CV (%)		7.75	8.05	4.67	4.02