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Effects of Filter Cake Fertilization on Weed Infestation, Disease Incidence and Tuber Yield of Cassava (*Manihot esculenta*) in Swaziland

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is a tuber crop newly introduced in Swaziland. Filter cake is a byproduct of sugarcane processing. In this research, cassava (varieties Nyasa & Line 65) was grown in the field, using filter cake as a fertilizer with the objective to determine the effects of filter cake on weed infestation, disease incidence, insect pest infestation, and storage root yield. Results showed that filter cake improved cassava tuber yields (no filter cake, 400-1,090 kg ha^{-1}; with filter cake, 975-3,510 kg ha^{-1}). Weed infestation was negatively correlated to tuber yield at 12 weeks after planting (WAP) ($r = -0.714$; $R^2 = 0.5098$; $p < 0.01$) and 32 WAP ($r = -0.390$; $R^2 = 0.1521$; significant, $p > 0.05$). Nyasa variety was more infected by cassava leaf mosaic (disease score, 4.5 out of 6.0), than Line 65 (disease score, 2.4 out of 6.0). Insect pest scores were significantly ($p < 0.01$) higher for Nyasa (insect pest score, 3.8 out of 6.0) than for Line 65 (insect score, 2.0 out of 6.0). The storage root yield (2,893 kg ha^{-1}) of Line 65 was significantly ($p < 0.01$) higher than Nyasa (1,443 kg ha^{-1}). To conclude, Line 65 is recommended under filter cake application at 60 t ha^{-1}.

Key Words: Cassava; Disease incidence; Filter cake; Filter mud; Pest incidence; Tuber yield

INTRODUCTION

Manihot esculenta Crantz is a tuber crop commonly known as cassava, yucca or tapioca is newly introduced in Swaziland. In *siSwati* national language of Swaziland, cassava is known as *umjumbula*. It is a drought-tolerant (Onwueme & Sinha, 1991), energy-storing root or tuber crop (Purseglove, 1987). Higher food prices, increased market access for farmers, and higher cassava yields are the primary factors that have played a role in cassava's emergence as a cash crop in most of the Southern Africa Development Community (SADC) region (Nweke, 1992). Cassava is expected to complement two other tuber root crops grown in Swaziland: sweetpotato (*Ipomoea batatas*) and Irish potato (*Solanum tuberosum*). Taro (*Colocasia antiquorum*) and tannia (*Xanthosoma saggitifolium*) as corms are also cultivated in Swaziland. Nonetheless, cassava production could lead to improved food security, in the face of persistent drought that has ravaged Southern Africa region for several years.

Filter cake is a soil-like byproduct of sugarcane processing and is considered a waste product produced in large quantities by the two sugar mills (Barnes, 1974; Ando *et al*., 2002). Cassava is cultivated in several countries in the SADC region including Botswana, Lesotho, Tanzania and Zambia (Acland, 1991) but in none of these countries is filter cake extensively used as a fertilizer. It is also not used on a large scale by farmers in Swaziland. However a recent development in the sugar industry in Swaziland is that some sugarcane plantations now apply filter cake on their farms to improve the growth of ratoon crop. Since filter cake has been used as fertilizer on sugarcane fields, this waste product has the potential to be used as a fertilizer in cassava production. It had been shown that soil amendments could be beneficial in crop production (Ranjha *et al*., 2001). Various fertilizer amendments have previously been investigated to observe their influence on nutrient availability (Khalil *et al*., 2002).

Weeds are a serious concern in crop production throughout sub-Saharan Africa, especially in those areas with semi-arid and arid conditions, where some parasitic weeds such as *Striga* sp. (witchweed) and *Cuscuta* sp. (dodder) are also problems (Riches, 2008). Weeds especially parasitic ones compete with crop plants and limit the resources for crop production.

Industrial waste management is one of the major problems faced by sugar-processing mills. In Kenya, it was suggested that one way of improving the problem of the sugar sub-sector was to use bagasse (the dry, dusty pulp that remains after juice is extracted from sugarcane) to produce newsprint, paper and putting filter cake into an economic use as an organic fertilizer or soil ameliorate (Odek *et al*.,

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2003). Factory waste products have been used on farms for soil enrichment or other beneficial purposes. Common examples include coffee (*Coffea* sp.), cocoa (*Theobroma cacoa*) and sugarcane (*Saccharum officinarum*), in which factory wastes have been utilized as soil amendments (Bressani & Braham, 1980; Ng Kee Kwong & Deville, 1988; Ossom *et al*., 2001). The use of soil amendments (crop residues, animal manure & composts) to improve soil properties has been recognized by agriculturists for centuries (Miller & Donahue, 1990; Chausavathi & Treloges, 2001). The use of filter cake as fertilizer in Swaziland has been investigated in maize (*Zea mays* L.) and sweetpotato (Ossom & Nxumalo, 2006; Ossom & Rhykerd, 2007), but no investigations on filter cake use in cassava production have been conducted in Swaziland.

The major components of filter cake and their concentrations are: moisture, 76%; bagasse or fibre, 12% and wax, 9%, MgO, 9450 mg/kg; CaO, 10500 mg/kg; K_2O, 4500 mg/kg; P_2O_5, 4470 mg/kg and available nitrogen, 50 mg/kg (Zhang & Hashimoto, 1996). Because of infertile and acidic soils, farmers in Swaziland typically use synthetic fertilizers to boost crop yields. But these fertilizers are costly; it would be expedient to investigate an alternative nutrient source for use in cassava production and the effects of such a nutrient source on the agricultural environment. Therefore this experiment was conducted to determine the effects of filter cake on weed infestation, disease and insect pest incidence and cassava storage root yield.

MATERIALS AND METHODS

Location and land preparation: The experiment was conducted at the Crop Production Department Experimental Farm in the Faculty of Agriculture, University of Swaziland in Luyengo (26.34°S, 31.10°E; height above sea level, 732.5 m; mean annual temperature, 18°C; mean annual rainfall range, 850-1000 mm) from December 2007 to August 2008. Luyengo is in the Middleveld agro-ecological zone of Swaziland. The soil was an Oxisol of the M-set (Malkerns series). The land was ploughed with a mouldboard plough, after which disc harrowing was done. Ridges were thereafter constructed using tractor-mounted ridgers.

Experimental design: The experimental design was a randomized complete block of 10 treatment combinations (Table I): two varieties of cassava (Nyasa & Line, 65) and five levels of filter cake (and 1 level of compound fertilizer), with a factorial arrangement. Each treatment was replicated four times. The gross plot size was 10.0 m long and 7.0 m wide and consisted of seven ridges or rows. The net plot consisted of 3 rows each measuring 10.0 m in length. Contiguous plots were separated by a 1.0-m space; a 1.0-m perimeter space surrounded the entire experiment. The selection of application rates for the filter cake and fertilizer was based on rates and results of previous investigations (Ossom & Nxumalo, 2006; Ossom & Rhykerd, 2007).

Filter cake and fertilizer application and planting: One composite sample of the soil and filter cake were chemically analyzed using standard analytical procedures (AOAC, 1990) at the start of experiment. Filter cake obtained from Ubombo Sugar mill, Ubombo, Swaziland, was applied on top of the ridges and worked into the soil using spades and garden forks before planting. In the first week of December 2007, fertilizers were applied; 300 kg ha^{-1} of N: P: K [2: 3: 2 (22)], that also contained 0.5% Zn, was applied only to the plots that required a fertilizer treatment (Treatments 5 & 10). Such plots also received 100 kg ha^{-1} of superphosphate (10.5% P) and 100 kg ha^{-1} of KCl (60% K). In each case, the method of application was banding and incorporation, 15 cm away from the planting rows.

Disease-free cassava cuttings of Nyasa and Line 65 were obtained from Malkerns Research Station, Malkerns, Swaziland. Cuttings (30 cm long) excised from mature cassava stems, were planted on top of the ridges, at an angle of about 45° from the horizontal with 5 cm of each cutting being below the soil surface (Howeler, 2004). Planting was done on weed-free, 1 m ridges in the second week of December 2007. To simulate the small-scale farmer's practice of minimal use of agro-chemicals, no chemical treatment of cuttings before planting was done. Meteorological information during the period of the investigation was obtained from records kept at Malkerns Research Station.

Crop management and harvest: Crop management consisted of general weeding using hand hoes at 4 and 8 WAP and weekly monitoring for insect pests and diseases. Tuber harvest was done at 32 WAP, using garden forks and spades to dig up the tubers.

Data collection and analysis: Weed infestation was scored at 12 and 32 WAP using weed scores and assessment methods previously applied (Daisley *et al*., 1988; Ossom, 2007) to assess weed infestation on a scale of 1-6 on the soil within a 100 cm square quadrat (three determinations per plot). Weed species were identified with the aid of weed manuals and books. Insect pests, the degree of insect damage and disease incidence within a 100-cm quadrat (four determinations per plot) were identified and scored at 32 WAP, using a scale of 1-6. Data were analyzed using MSTAT-C software, version 1.3 (Nissen, 1983); separation of means was done by the least significant difference test (Steel *et al*., 1997).

RESULTS AND DISCUSSION

Meteorological data: Meteorological information during the period of the investigation is shown in Table II. Total rainfall during the period was 618.5 mm; the mean temperature ranged from a low of 8.7ºC in July 2008, to a high of 28.7ºC in February 2008. Among the climatic factors that could influence crop growth and performance are rainfall amounts and distribution, as well as air and soil temperatures. The cropping period was much drier than the same months for the previous 10 years (1997-2007, data now shown) that had a mean annual rainfall of 113.5 mm.

Initial soil and filter cake properties: The chemical characteristics of the soil at the beginning of the investigation were: pH, 5.6; N, 0.11%; P, 0.69%; K, 2.84%; exchangeable acidity, 0.15 cmole kg^{-1} and organic matter, 2.72%. The soil appeared low in nitrogen with moderate concentrations of P and K. The chemical properties of the filter cake were as follows: pH, 7.98; N, 1.77%; P, 2340.0 cmole kg^{-1}; K, 999 cmole kg^{-1}; Mg, 37.89 cmole kg^{-1}; Ca, 10.15 cmole kg^{-1} and exchangeable acidity, 0.10 cmole kg^{-1}. As noted the pH of the filter cake was in the alkaline range that would have complemented the soil pH (acidic). Perry (1997) reported the optimum pH range for sweetpotato to be 5.2-6.0; on this account, it would be proper to assume that the soil pH of 5.6 was adequate. Havlin *et al*. (2005) reported that an increase in soil acidity could be attributed to the release of H during nitrification of any added ammonium fertilizer. Additions of organic matter (such as filter cake) to soil can reduce the effects of soil acidity and particularly, Al toxicity (Hargrove & Thomas, 1981; Wong *et al*., 1995).

Weed infestation: Tables III and IV show the influence of filter cake fertilization on weed species distribution at 12 and 32 WAP. Weeds that were ubiquitous in all treatments at 12 WAP were: *Oxalis latifolia*, *Cleome gynandra*, *Cynodon dactylon* and *Richardia brasiliensis.* At 32 WAP, the weeds most prevent in all plots were: *Bidens pilosa*, *Cynodon dactylon* and *Richardia brasiliensis*. Both *Oxalis latifolia* and *Bidens pilosa* are weeds that are harvested in the wild and sold as vegetables in Swaziland. The proliferation of such weeds in all plots was an indication of the presence of a large seed bank of such weeds in the experimental plots. At 12 WAP, weed scores (Table V) were significantly ($p < 0.01$) higher in plots under Nyasa (weed scores, 4.9 out of 6.0) than under Line 65 (4.0 out of 6.0), but the weed score differences were not significantly different among the soil amendments. Weed densities were generally lower as the cropping season progressed, indicating the shading and smothering influences of the cassava on weeds later in the cropping season. The mean weed densities for the soil amendment materials were as follows: control, 4.7 out of 6.0; 20 t ha^{-1} of filter cake, 4.3 out of 6.0; 40 t ha^{-1} of filter cake, 4.3 out of 6.0; 60 t ha^{-1} of filter cake, 4.4 out of 6.0 and 300 kg ha^{-1} of artificial fertilizer, 4.4 out of 6.0. Weed scores at both 12 WAP ($r = -0.714$; $R^2 = 0.5098$; significant at $p < 0.01$) and 32 WAP ($r = -0.390$; $R^2 = 0.1521$; not significant) were negatively correlated to tuber yield. The observed effects of weeds reducing tuber yield were consistent with previous reports (Ossom *et al*., 2005; Zimdahl, 2007) in which the adverse effects of weeds on crop production were reported. There were no weed species alien to the Malkerns area and that could be suspected to have been introduced from the filter cake source.

Insect pest and disease incidence: Insect pest and disease scores at 32 WAP are shown in Table V. Insect pest scores were significantly ($p < 0.01$) higher for Nyasa (insect pest score, 3.8 out of 6.0) than for Line 65 (insect score, 2.0 out of 6.0). Among the soil amendments, the disease score means were as follows: control, 4.0 out of 6.0; 20 tonnes ha^{-1} of filter cake, 3.5 out of 6.0; 40 tonnes ha^{-1} of filter cake, 3.7 out of 6.0; 60 tonnes ha^{-1} of filter cake, 3.1 out of 6.0 and 300 kg ha^{-1} artificial fertilizer, 2.9 out of 6.0. The two diseases that affected the cassava were *Cercospora* leaf-spot and cassava mosaic. Both diseases infected Nyasa more than on Line 65. Fig. 1 and 2 show cassava plants of Nyasa variety (heavily infected with cassava mosaic disease) and Line 65 showing no disease symptoms at 32 WAP. Common diseases associated with sugarcane production were not encountered in this investigation. Non-appearance of sugarcane-associated insect pests and diseases (Rott *et*

Table I: Treatment description for the experiment

Treatment code	Cassava variety	Rate of filter cake (tonnes ha^{-1})	Rate of compound fertilizer (kg ha^{-1})
1	Nyasa	0 (Control)	0
2	Nyasa	20	0
3	Nyasa	40	0
4	Nyasa	60	0
5	Nyasa	0	300
6	Line 65	0 (Control)	0
7	Line 65	20	0
8	Line 65	40	0
9	Line 65	60	0
10	Line 65	0	300

Table II: Meteorological data during the period of investigation

Month	Mean air temperatures (°C)		Mean monthly rainfall (mm)
	Maximum	Minimum	
December 2007	27.1	16.9	111.7
January 2008	27.1	18.2	81.9
February 2008	28.7	17.3	75.0
March 2008	26.4	16.5	195.6
April 2008	23.9	13.1	95.7
May 2008	25.6	11.4	22.2
June 2008	22.8	9.0	25.0
July 2008	24.2	8.7	4.8
August 2008	26.3	10.6	6.6
Totals	232.1	121.7	618.5
Means	25.8	13.5	68.7

Fig. 1: Leaves of Nyasa variety showing symptoms of cassava mosaic virus disease

Table III: Distribution and relative abundance of weed species under filter cake fertilization at 12 weeks

Weed species	Common name	Treatment code[1] of soil amendment material									
		1	2	3	4	5	6	7	8	9	10
Bidens pilosa L.	Common blackjack	+	-	-	-	+	+	+	-	+	-
Cleome gynandra L.	Spider wisp	+	+	+	+	+	+	+	+	+	+
Commelina benghalensis L.	Wandering Jew	-	+	+	+	-	-	-	+	+	+
Convolvulus arvensis L.	Field bindweed	-	+	+	+	-	+	+	+	+	+
Crotalaria juncea L	Sunnhemp	-	-	-	-	-	-	-	+	-	-
Cynodon dactylon (L.) Pers.	Star grass	+	+	+	+	+	+	+	+	+	+
Cyperus esculentus L.	Yellow nutsedge	-	+	-	+	-	-	+	+	-	-
C. rotundus L.	Purple nutsedge	+	+	-	+	+	+	+	+	+	-
Desmodium intortum	Silver-leaf Desmodium	-	-	-	-	-	-	-	-	-	-
Euphorbia heterophylla L.	Painted milkweed	+	-	+	-	-	-	+	+	+	-
Galinsoga parviflora Cav.	Gallant soldier	-	-	-	+	-	-	-	-	-	-
Hibiscus trionum	Bladder Hibiscus	+	+	+	-	+	+	+	-	-	-
Ipomoea batatas (L.)	Sweetpotato	+	-	+	-	-	+	-	-	-	+
I. purpurea (L.) Roth.	Morning glory	+	+	+	+	+	+	+	+	+	+
Leucas martinicensis Jacq.	Bobbin weed	-	-	-	-	-	-	-	+	-	-
Nicandra physalodes (L.) Gaertn.	Apple of Peru	+	+	+	+	+	+	-	+	+	+
Oxalis latifolia H. B. K.	Red garden sorrel	+	+	+	+	+	+	+	+	+	+
Panicum maximum L.	Guinea grass	+	-	+	-	+	+	+	+	-	-
Richardia brasiliensis Gomes.	Tropical Richardia	+	+	+	+	+	+	+	+	+	+
Sida cordifolia L.	Heartleaf Sida	-	+	-	-	-	-	-	-	-	-
Tagetes minuta L.	Mexican marigold	+	-	+	-	-	-	+	-	-	-
Weed score	N/A	5.1a	4.7b	4.8a	4.8a	5.3a	4.4b	4.1b	3.8a	4.0a	3.6c

[1]Treatment codes as described in Table I
N/A, not applicable
+, weed species present; -, weed species absent, Numbers followed by the same letters in the same column are not significantly different

Table IV: Distribution and relative abundance of weed species under filter cake fertilization at 32 weeks

Weed species	Common name	Treatment code[1] of soil amendment material									
		1	2	3	4	5	6	7	8	9	10
Ageratum conyzoides L.	Goat weed	+	-	+	+	+	+	+	+	+	+
Bidens pilosa L.	Common blackjack	+	+	+	+	+	+	+	+	+	+
Centrosema mollе Benth.	Centro	-	-	-	+	-	-	-	-	-	-
Cleome gynandra L.	Spider wisp	+	+	+	-	+	-	-	-	-	-
Commelina benghalensis L.	Wandering Jew	+	-	+	+	+	-	-	-	-	-
Convolvulus arvensis L.	Field bindweed	-	-	-	-	-	-	+	-	-	-
Cynodon dactylon (L.) Pers.	Star grass	+	+	+	+	+	+	+	+	+	+
Cyperus rotundus L.	Purple nutsedge	+	+	+	+	-	+	+	+	-	+
Euphorbia heterophylla L.	Painted milkweed	+	-	-	-	-	-	-	+	-	-
Hibiscus trionum	Bladder Hibiscus	-	+	-	-	-	+	+	+	-	-
Ipomoea batatas (L.)	Sweetpotato	-	-	-	-	-	+	-	-	-	-
Nicandra physalodes (L.) Gaertn.	Apple of Peru	+	-	+	+	+	-	+	+	+	+
Oxalis corniculata L.	Creeping sorrel	-	-	-	-	-	+	+	-	-	-
O. latifolia H. B. K.	Red garden sorrel	-	+	-	-	-	-	-	-	+	-
Panicum maximum L.	Guinea grass	-	+	+	-	+	+	-	+	+	+
Plantago major L.	Common *plantain*	-	-	-	-	-	-	-	-	+	+
Richardia brasiliensis Gomes.	Tropical Richardia	+	+	+	+	+	+	+	+	+	+
Schkuhria pinnata Lam.	Dwarf marigold	-	-	-	-	-	-	-	+	-	+
Sida cordifolia L.	Heartleaf Sida	+	-	-	-	+	-	+	-	-	+
Solanum mauritianum L.	Bugtree	-	-	-	-	-	-	-	+	-	+
S. sisymbriifolium L.	Sticky nightshade	-	-	-	-	-	-	-	-	-	+
Sonchus olearaceus L.	Sowthistle	-	-	-	+	+	+	+	-	+	+
Weed score	N/A	3.4b	3.2b	2.8c	4.0a	3.6b	3.6b	3.3b	3.5b	3.4b	3.0b

[1]Treatment codes as described in Table I
N/A, not applicable
+, weed species present; -, weed species absent, Numbers followed by the same letters in the same column are not significantly different

al., 2000) during the investigation might imply that filter cake is not a likely source of these organisms in cassava cultivation. *Cercospora* leaf-spot and cassava mosaic are among the common problems associated with cassava production (CABI, 2000).

Storage root yield. The tuber yield (2893 kg ha^{-1}) of Line 65 was significantly ($p < 0.01$) higher than the tuber yield (1443 kg ha^{-1}) of Nyasa (Table VI). Cassava tuber yields (averaged over both varieties) relative to the amount of soil amendments applied were as follows: control, 745.0 kg ha^{-1}; 20 tonnes ha^{-1} of filter cake, 1,691.3 kg ha^{-1}, 40 t ha^{-1} of filter cake, 2,652.5 kg ha^{-1}; 60 t ha^{-1} of filter cake, 2,768.8

Table V: Weed score, disease and insect pest scores as influenced by filter cake fertilization of two cassava varieties

Cassava varieties	Fertilizer rates	Weed scores at 12 weeks	Weed scores at 32 weeks	Disease score at 32 weeks	Insect pest score at 32 weeks
Nyasa	No fertilizer	5.1a	3.4b	5.4a	4.6a
Nyasa	20 t ha^{-1} filter cake	4.7b	3.2b	4.1a	3.4a
Nyasa	40 t ha^{-1} filter cake	4.8a	2.8c	4.8b	4.1b
Nyasa	60 t ha^{-1} filter cake	4.8a	4.0a	4.8b	4.3a
Nyasa	300 kg ha^{-1} N:P:K	5.3a	3.6b	3.6ab	2.7
Mean		4.9	3.4	2.4	3.8
Line 65	No fertilizer	4.4b	3.6b	2.7a	2.2a
Line 65	20 t ha^{-1} filter cake	4.1b	3.3b	3.0a	2.7a
Line 65	40 t ha^{-1} filter cake	3.8a	3.5b	2.5a	2.1a
Line 65	60 t ha^{-1} filter cake	4.0a	3.4b	1.5a	1.3b
Line 65	300 kg ha^{-1} N:P:K	3.6c	3.0b	2.3a	1.8a
Mean	-	4.0	3.3	2.4	2.0
Grand mean	-	4.4	4.4	3.5	2.9
Standard error (V x F)	-	0.33	0.34	0.40	0.38

Numbers followed by the same letters in the same column are not significantly different

Table VI: Cassava harvest data at 32 weeks after planting

Cassava varieties	Fertilizer rates	Tuber yield (kg ha^{-1})	Tuber fresh mass per plant (g)	Tuber dry matter per plant (g)
Nyasa	No fertilizer	400.0a	91.9a	40.5a
Nyasa	20 t ha^{-1} filter cake	975.0b	129.4a	55.4b
Nyasa	40 t ha^{-1} filter cake	2457.5c	203.7b	75.6c
Nyasa	60 t ha^{-1} filter cake	2027.5c	153.0c	65.5d
Nyasa	300 kg ha^{-1} N:P:K	1355.0d	123.9c	66.1d
Mean		745.00	146.18	60.6
Line 65	No fertilizer	1090.0c	123.9a	50.9b
Line 65	20 t ha^{-1} filter cake	2407.5c	221.0b	58.5b
Line 65	40 t ha^{-1} filter cake	2847.5c	271.9c	87.1c
Line 65	60 t ha^{-1} filter cake	3510.0e	250.0d	80.6c
Line 65	300 kg ha^{-1} N:P:K	4610.0f	393.8e	95.4e
Mean	-	1691.25	252.10	74.5
Grand mean	-	2168.0	199.14	67.56
Standard error (V x F)	-	547.19	46.42	10.97
Significance	-	**	*	**

*,Significant at $p < 0.05$;
**,Significant at $p < 0.01$.
Numbers followed by the same letters in the same column are not significantly different

Fig. 2: Leaves of Line 65 variety showing no symptoms of any disease

kg ha^{-1} and 300 kg ha^{-1} artificial fertilizer, 2,982.5 kg ha^{-1}. However the interactive effects were not significant. One possible reason for the low tuber yields could be that the plants were harvested less than one year after planting; probably if they had been grown for some more months, they might have given higher yields.

Cassava yields vary widely from one part of the world to another. Researchers reported some cassava yield data as follows: 1.8 t ha^{-1} in the Sudan; 10.6 t ha^{-1} in Nigeria; and 27.3 t ha^{-1} in Barbados (IITA, 2000).

CONCLUSION

This investigation has shown that filter cake is a potential source of organic fertilizer in cassava production. Small-scale farmers should apply 60 t ha^{-1} of filter cake in cassava production, for best weed control and crop yield. Since no peak level filter cake was reached in this investigation, further investigation into filter cake use in cassava production should be encouraged in order to examine more specific roles of filter cake in cassava agronomy and physiology. Line 65 is a preferred variety to plant under filter cake fertilization.

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REFERENCES

Acland, J.D., 1991. *East African Crops: An Introduction to the Production of Field and Plantation Crops in Kenya, Tanzania and Uganda*. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

Ando, S., S. Meunchang, S. Thippayarugs, P. Prasertsak, N. Matsumoto and T.Y. Oneyama, 2002. Sustainability of sugarcane production evaluated based on organic matter cycle and nitrogen fixation. In: *Proc. 17th World Congress of Soil Science*, Paper No. 1948, 1–8. 14-21 August 2002, Bangkok, Thailand

Association of Official Analytical Chemists, 1990. *Official Methods of Analysis*, 15th editionn. Arlington, Virginia

Barnes, A.C., 1974. *The Sugar Cane*. John Wiley and Sons, Inc., Brumelle, New York

Bressani, R. and E.J. Braham, 1980. Utilization of coffee pulp as animal feed. In: *Neuvieme Colloque Scientifique International Sur Le Cafe, ASIC*, pp: 303–323. Paris, France

CABI, 2000. *Crop Protection Compendium 2004 edition*. CAB International Publishing, Wallingford, UK

Chausavathi, T. and V. Treloges, 2001. An improvement of Yasothon soil fertility (Oxic Paleustults) using municipal fermented organic compost and *Panicum maximum* TD 85 grass. *Pakistan J. Biol. Sci.*, 4: 968–972

Daisley, L.E.A., S.K. Chong, F.J. Olsen, L. Singh and C. George, 1988. Effects of surface-applied grass mulch on soil water content and yields of cowpea and eggplant in Antiqua. *Trop. Agric.*, 65: 300–304

Havlin, J.L., J.D. Beaton, S.L. Tisdale and W.L. Nelson, 2005. *Soil Fertility and Fertilizers*, 7th edition. Pearson Prentice Hall, Upper Saddle River, New Jersey, U.S.A

Hargrove, W.L. and G.W. Thomas, 1981. Effect of organic matter on exchangeable aluminum and plant growth in acid soils. *In: Chemistry in the Soil Environment*. American Society of Agronomy Special Publication no. 40, Madison, Wisconsin

Howeler, R., 2004. *World Fertilizer Use Manual*. http://www.fertilizer.org/ifa/publicat/html/pubman/cassava.htm. Accessed 04/09/04

IITA, 2000. *Cassava*. http://www.iita.org/cms/details/cassava_project.aspx?zonied=63&articleid=267. Accessed 07/08/09

Khalil, S., M.S. Zia and I.A. Mahmood, 2002. Biophos influence on P availability from rockphosphate applied to rice (*Oryza sativa* L) with various amendments. *Int. J. Agric. Biol.*, 4: 272–274

Miller, W.M. and R.L. Donahue, 1990. *Soils: An Introduction to Soils and Plant Growth*, 6th edition. Prentice Hall, Englewood Cliffs, NJ

Ng Kee Kwong, K.F. and J. Deville, 1988. Filter cake as a nitrogen fertilizer for plant cane in Mauritius. *Trop. Agric. (Trinidad)*, 65: 364–366

Nissen, O., 1983. *MSTAT-C–A Microcomputer Program for the Design, Management and Analysis of Agronomic Research Experiments*. Michigan State University, East Lansing, Michigan

Nweke, F.I., 1992. *Cassava: A Cash Crop in Africa*. COSCA working paper No. 4. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria

Odek, O., P. Kegode and S. Ochola, 2003. *The Challenges and Way Forward for the Sugar Sub-sector in Kenya*. Published by Friedrich Ebert Stiftung, P.O. Box 14932, Nairobi, Kenya

Onwueme, I.C. and T.D Sinha, 1991. *Field Crop Production in Tropical Africa*. The Technical Centre for Agricultural and Rural Co-operation (CTA) Ede, The Netherlands

Ossom, E.M., 2007. Influence of field bean (*Phaseolus vulgaris* L.) population on yield components, soil temperatures and weed infestation of sweetpotato [*Ipomoea batatas* L. (Lam.) in Swaziland. *Botswana J. Agric. Appl. Sci.*, 3: 129–138

Ossom, E.M. and M.H. Nxumalo, 2006. Effects of filter cake on agronomic characteristics and yield of maize (*Zea mays* L.) in Swaziland. *UNISWA J. Agric.*, 14: 81–89

Ossom, E.M. and R.L. Rhykerd, 2007. Response of *Ipomoea batatas* (L.) Lam. to soil fertilization with filter cake. *Trans. Illinois State Acad. Sci.*, 100: 197–208

Ossom, E.M., O.T. Edje and M.H. Nxumalo, 2005. *Effects of Growing Cassava and Grain Legume Crops in Monoculture and in Association*, p: 79. Final report submitted to UNISWA Research Board, University of Swaziland, Kwaluseni, Swaziland

Ossom, E.M., P.F. Pace, R.L. Rhykerd and C.L. Rhykerd, 2001. Effect of mulch on weed infestation, soil temperature, nutrient concentration and tuber yield in *Ipomoea batatas* (L.) Lam. in Papua New Guinea. *Trop. Agric. (Trinidad)*, 78: 144–151

Perry, L.P., 1997. *pH for the Garden*. http://www.uvm.edu/extension/publications/oh/oh34.htm. Accessed 04/07/06

Purseglove, J.W., 1987. *Tropical Crops–Dicotyledons*. Longman Group Limited, London

Ranjha, A.M., I. Ahmad, M. Iqbal and M.J. Ahmad, 2001. Rice response to applied phosphorus, zinc and farmyard manure. *Int. J. Agric. Biol.*, 3: 197–198

Riches, C., 2008. *Research at NRI–Weed Science*. http://www.nri.org/research/weedscience.htm. Accessed 08/04/08

Rott, P., R.A. Bailey and S.A. Saumtally, 2000. *A Guide to Sugarcane Diseases*. Elsevier Publishing Company, New York

Steel, R.G.D., J.H. Torrie and D.A. Dickey, 1997. *Principles and Procedures of Statistics: A Biometric Approach*, 3rd edition. McGraw-Hill, New York

Wong, M.T.F., E. Akyeampong, S. Nortcliff, M.R. Rao and R.S. Swift, 1995. Initial responses of maize and beans to decreased concentrations of monomeric inorganic aluminum with applications of manure or tree prunings to an Oxisol in Burundi. *Plant Soil*, 171: 275–282

Zhang, G. and H. Hashimoto, 1996. *Soil Waste Management and Control*. www.dti.gov.uk/energy/renewables/publications/pdfs/BWM 00542.pdf. Access date. 08/09/04

Zimdahl, R.L., 2007. *Fundamentals of Weed Science*, 3rd edition. Academic Press, New York

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