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Effects of filtermud on growth and yield of three banana cultivars grown in Kenana Sugar Scheme area, central Sudan

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ABSTRACT

Banana is an important fruit crop in the Sudan and its production is mainly confined to the alluvial deposits of rivers. Organic matter is known to improve soil physical and chemical characteristics and provide plant mineral nutrients. Therefore, the objective of this research was to evaluate the effects of filtermud levels on vegetative growth, yield components and total yield of the mother, first, second and third ratoon crops of three banana cultivars. Field experiments were conducted during December 2012 to November 2014 at Kenana Sugar Scheme area. Banana cultivars were the introduced banana clones Williams Hybrid and Grand Nain and the local cultivar Dwarf Cavendish. Levels of filtermud were 15% and 30% by volume. Treatments were arranged in a randomized complete block design with four replicates. Three months after planting, two plants from each plot were randomly selected, tagged and used for growth and yield measurements. Results showed significant differences among cultivars in vegetative growth, yield components and total yield. The introduced banana clones Williams Hybrid and Grand Nain had the most vigorous vegetative growth and the highest yield components and total yield compared to that of the local cultivar Dwarf Cavendish. However, Dwarf Cavendish was earlier than the introduced clones. Application of filtermud at both rates resulted in a significant increase in all vegetative growth parameters and in the earliness of banana crop. Filtermud also produced a significant increase in all yield components and total yield compared to the untreated control. It is recommended to grow the introduced cultivars Williams Hybrid and Grand Nain and apply filtermud at the rate of 15% by volume in heavy clay soils.

INTRODUCTION

Banana is the most popular fruit in the Sudan for its high nutritive value, low price and availability all year round. It is cultivated in an area of about 23000 ha mainly for local consumption (Bakhiet *et al.,* 2011). It is grown in the alluvial deposits of the River Nile, Kassala State in the Gash basin, along the Blue Nile south of Sennar and in Wad Ramli and Surorab, north of Khartoum , with an annual production of 74 thousand metric tons (FAO, 2004). The commonly grown cultivar in the Sudan is the Dwarf Cavendish which is a low yielder and does not meet international market requirements. In recent years, Williams Hybrid and Grand Nain cultivars were introduced from South Africa and evaluated in central Sudan and showed high yields with good fruit quality (Elkashif *et al*., 2014; Mahmoud and Elkashif, 2003).

Filtermud, which is a by-product of sugar factories, is a potential source of macro and micro-elements. Also, it improves physical and chemical properties of soils. Recently, the high cost of fertilizers and concerns about environmental hazard have promoted incentives for studying the recycling of the large quantities of organic residues produced as by-products of the sugar industry. Filtermud is produced in large volumes (30–40 $kg/t^{-1}$of crushed cane) and contains a considerable amount of organic matter and mineral elements required for plant nutrition. Filtermud improves soil chemical properties by increasing nitrogen, phosphorus, and calcium concentrations, cation exchange capacity.

Therefore, the objective of this study was to determine the effects of filtermud levels on the vegetative growth, yield components and total yield of the mother, first, second and third ratoon crops of three banana cultivars.

MATERIALS AND METHODS

Field experiments were conducted at Kanana Sugar Scheme area, White Nile State, Sudan. The land was ploughed, leveled and made into 4m x 5m plots and each plot consisted of four plants. Pits (50 cm x 50 cm x 50 cm) were dug and filtermud was applied at the levels of 15% and 30% by volume. The composition of filtermud is shown in Table 1 (Samuels and Landraw, 1956). Nitrogen in the form of urea was applied at 43 kg/ha at planting and then every four months. Sword suckers of three banana cultivars (Williams Hybrid, Grand Nain and Dwarf Cavendish)

were transplanted at a spacing of 2 m x 3 m in December 2012. Treatments were arranged in a randomized complete block design with four replicates. The plots were irrigated every 7 days according to weather conditions. Weed control and other cultural practices were carried out as recommended (Elkashif *et al*., 2014).

Table 1. Composition of filter mud

Element	% on dry basis
N	2.19
P as P_2O_5	2.77
K as K_2O	0.44
Ca as CaO	3.05
Mg as MgO	0.49
Mn as MnO_2	0.27
Fe as Fe_2O_3	1.05
B as B_2O_3	0.01
Organic matter	39.5

Growth measurements

Three months after planting, two plants from each plot were randomly selected, tagged and used for growth measurements.

Number of leaves, leaf area, plant height, and pseudostem girth were measured at monthly intervals. Leaf area was calculated as the product of length and width times a factor of 0.8 as described by Murray (1960). Plant height measurements were taken 5 cm above the ground level up to the point of intersection of the petioles of the two youngest leaves. Pseudostem girth was measured at 5 cm above the ground level. Also, the number of days from planting to shooting were recorded.

Yield components and total yield

Bunches were harvested when fruits were at the mature- green, full three quarter stage and weighed. Hands and stalks were separately weighed. Number of hands per bunch, number of fingers per hand, finger length, and total yield were determined.

Statistical analysis

Data were analysed using the standard analysis of variance procedures. Means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

Table 2 showed the main effects of banana cultivars on the vegetative growth of the mother crop at shooting and number of days from planting to shooting. There were significant differences between cultivars in all vegetative growth parameters except number of leaves. The introduced cultivars Williams Hybrid and Grand Nain recorded the most vigorous vegetative growth compared to that of the local cultivar Dwarf Cavendish. These findings were in line with those reported by Elkashif *et al*.(2014; 2015) and Elsiddig *et al.* (2009). Pseudostem height is a very important growth parameter of banana in arid and semi-arid tropical regions. A tall pseudostem makes banana plants vulnerable to toppling during strong winds frequently occurring in that climate. This necessitates propping of plants, especially when they are bearing bunches. The short pseudostem of Dwarf Cavendish cultivar is an important advantage in tropical climate with respect to this toppling phenomenon.

There were highly significant differences between cultivars in number of days from planting to shooting. The introduced cultivars Williams Hybrid and Grand Nain scored more number of days from planting to shooting which indicated that they were slightly late cultivars than the local cultivar Dwarf Cavendish.

Table 2. Main effects of banana cultivars on the vegetative growth at shooting and number of days from planting to shooting of the mother crop.

Cultivars	No. of leaves	Leaf area (m^2)	Stem height (cm)	Stem girth (cm)	No. of days to shooting
Dwarf Cavendish	18.8	0.65 b	127.0 c	43.4 b	311.6 b
Grand Nain	18.5	0.86 a	133.6 b	47.9 a	321.8 a
Williams Hybrid	18.3	0.89 a	144.3 a	48.1a	325.8 a
Sig. level	NS	*	*	*	**
C.V%	6.62	13.38	12.82	10.49	6.57

Means in columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.
*, ** and NS indicate significance at P≤0.05, 0.01 and not significant, respectively.

The main effects of filter mud levels on the vegetative growth of banana mother crop at shooting and number of days from planting to shooting are shown in Table 3. Application of filter mud at both rates resulted in a highly significant increase in all vegetative growth parameters of bananas, except number of leaves, which is controlled by genetic factors. This indicates that filter mud resulted in a strong vegetative growth of banana by improving the physical and chemical properties of the heavy clay soils in Kenana Sugar Scheme area. These results support the findings reported by Ekashif *et al*. (2014). Filter mud also significantly resulted in the shortest period from planting to shooting, which indicated that it had a positive effect on the earliness of banana crop. These results open new avenues for extending the cultivation of bananas to the heavy clay soils of the Sudan.

Table 3. Main effects of filter mud levels on the vegetative growth of banana mother crop at shooting and number of days from planting to shooting.

Filter mud levels (%)	No. of leaves	Leaf area (m^2)	Stem length (cm)	Stem girth (cm)	No. of days to shooting
0	18.4	0.69 b	134.5 b	47.3 b	332.3 a
15	18.5	0.87 a	139.3 a	55.7 ab	309.4 b
30	18.6	0.88 a	140.0 a	57.4 a	305.5 b
Sig. level	NS	*	**	*	**
C.V%	6.62	19.38	12.82	10.49	6.57

Means in columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.
*, ** and NS indicate significance at P≤0.05, 0.01 and not significant, respectively.

Table 4 showed highly significant interaction between cultivars and filter mud on all vegetative growth parameters of banana mother crop at shooting, except number of leaves. The most vigorous vegetative growth was obtained by the introduced cultivars Williams Hybrid and Grand Nain which received both rates of filtermud.

The relatively few number of days from planting to shooting was recorded for Dwarf Cavendish and the introduced cultivars Williams Hybrid and Grand Nain which received both rates of filter mud. Needless to say, more number of days from planting to shooting was recorded for the local cultivar Dwarf Cavendish without filter mud treatment. This indicates that filter mud was effective in the early maturity of bananas.

Table 4. Interaction between cultivars and filter mud levels on the vegetative growth of banana mother crop at shooting and number of days to shooting.

Cultivars	FM (%)	No. of leaves	Leaf area (m^2)	Stem length (cm)	Stemgirth (cm)	No of days to shooting
DC	0	18.4	0.65 c	119.3 e	45.9 c	367.5 a
	15	18.9	0.75 b	124.0 de	47.8 b	292.8 e
	30	18.3	0.78 b	128.3 d	48.5 ab	291.5 e
GN	0	18.3	0.67 c	130.1 cd	46.6 b	356.8 ab
	15	18.0	0.83 ab	144.5 b	48.5 ab	306.3 cd
	30	18.5	0.85 ab	146.3 b	49.6 a	301.3 cd
WH	0	18.6	0.65 c	135.6 c	46.2 b	351.5 ab
	15	18.5	0.86 a	152.5 a	48.1 ab	329.3 b
	30	19.1	0.89 a	154.6 a	49.0 a	316.8 c
Sig. level		NS	*	**	**	**
C.V%		6.62	19.38	12.82	10.49	6.57

Means within columns followed by the same letter(s) are not significantly different at $P<0.05$ level according to Duncan's Multiple Range Test.

*, * * and NS indicate significance at $P\leq0.05$, 0. 01 and not significant, respectively.

DC=Dwarf Cavendish, GN=Grand Nain, WH=Williams Hybrid. FM=filter mud.

Yield and yield components

The main effects of banana cultivars on yield and yield components are significant (Table 5). The introduced cultivars Williams Hybrid and Grand Nain resulted in the highest yield components and total yield compared to that of the local cultivar Dwarf Cavendish. These results are in conformity with the vegetative growth data shown in Table 2. Elkashif *et al*. (2014; 2015) and Elsiddig *et al.* (2009) reported that introduced banana cultivars out-yielded the local Dwarf Cavendish cultivar.

Table 5. Main effects of banana cultivars on yield and yield components of the mother crop.

Cultivars	H/B	F/H	BW (kg)	FL (cm)	TY (ton/ha)
Dwarf Cavendish	6.7	13.7	11.6	15.3	19.3
Grand Nain	8.4	17.2	16.7	18.2	27.8
Williams Hybrid	9.6	18.5	17.8	19.8	29.6
Sig. level	*	*	*	*	**
C.V%	10.59	18.89	10.75	10.24	10.76

Means within columns followed by the same letter(s) are not significantly different at $P<0.05$ level according to Duncan's Multiple Range Test.

* and * * indicate significance at $P\leq0.05$ and 0. 01, respectively.

H/B=number of hands per bunch, F/H=number of fingers per hand, BW=bunch weight, FL=finger length and TY=total yield.

The main effects of filter mud levels on yield and yield components of bananas are shown in Table 6. Application of filter mud at both rates resulted in a significant increase in all yield components and total yield compared to that of the control. These results are supported by the vegetative growth data shown in Table 3. This data suggest that filter mud cake had positive effects on the improvement of the physical properties of the heavy clay soils of Kenana Sugar Scheme area, in addition to the supply of macro and micronutrients (Table 1). Elkashif *et al* (2014) reported that application of chicken manure significantly increased yield components and total yield of selected banana cultivars.

Table 6. Main effects of filter mud levels on yield and yield components.

Filter mud levels (%)	H/B	F/H	BW (kg)	FL (cm)	TY (ton/ha)
0	6.9 b	12.5 b	11.2 b	16.2 b	18.7 b
15	8.2 a	15.0 a	17.7 a	18.8 a	29.5 a
30	9.5 a	16.1 a	18.2 a	19.7 a	30.3 a
Sig. level	*	*	*	*	**
C.V%	10.59	18.89	10.75	10.24	10.76

Means within columns followed by the same letter(s) are not significantly different at P<0.05level according to Duncan's Multiple Range Test.

* and ** indicate significance at P≤0.05 and 0. 01, respectively.
H/B=number of hands per bunch, F/H=number of fingers per hand, BW=bunch weight, FL=finger length and TY=total yield.

Table 7 showed significant interaction between banana cultivars and filter mud levels on all yield components and total yield. The highest values were obtained by the introduced cultivars Williams Hybrid and Grand Nain which received both rates of filter mud and the lowest values were obtained by the local cultivar Dwarf Cavendish without filter mud. These results are in agreement with those reported by Mohamoud (2000) and Mahmoud and Elkashif (2003) who showed that Dwarf Cavendish cultivar gave the lowest yield and yield components.

Table 7. Interaction between banana cultivars and filter mud levels on yield components and total yield.

Cultivars	Filter mud levels (%)	H/B	F/H	W (kg)	FL (cm)	TY ton)ha
DC	0	6.8 cd	13.4 cd	1.4 cd	15.1c	8.9 cd
	15	7.3 c	14.2 c	2.3 c	16.3 c	0.5 c
	30	7.5 c	14.7 c	2.5 c	16.5 c	1.2 c
GN	0	8.3 b	17.3 b	6.3 bc	18.3 b	7.0 b
	15	8.7 ab	18.5 ab	7.5 b	19.4 ab	9.2 ab
	30	8.9 ab	18.8 ab	7.8 ab	19.7 ab	9.7 a
WH	0	9.4 a	18.2 ab	7.2 b	19.5 ab	8.8 ab
	15	9.6 a	19.4 a	8.4 a	20.7 a	0.3 a
	30	9.7 a	19.7 a	8.6 a	20.8 a	0.7 a
Sig. level		*	*	**	**	**
C.V%		10.59	12.89	10.75	10.24	10.76

Means within columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.
*, and * * indicate significance at P≤ 0.05 and 0.01, respectively.
H/B=number of hands per bunch, F/H=number of fingers per hand, BW=bunch weight, FL=finger length and TY=total yield.
DC=Dwarf Cavendish, GN=Grand Nain, WH=Williams Hybrid

Table 8 showed highly significant interaction between cultivars and filter mud on the total yield of mother, first, second and third ratoon crops. Results showed that the highest yields of the mother crop and three ratoons were obtained by the introduced cultivars Williams Hybrid and Grand Nain which received both rates of filter mud and the lowest yield values were obtained by the local cultivar Dwarf Cavendish without filter mud. Also, there was a progressive increase in total yield from the mother crop to the third ratoon. This phenomenon is observed in all banana plantations. It is most probably due to the increase in the development and proliferation of the root system of bananas which made it more capable of water absorption and nutrient uptake. It might also be due to the decomposition of filter mud which is accompanied by the release of plant mineral nutrients.

These results are in agreement with those reported by Mahmoud *et al.* (2011) who found a significant increase in the yield of the first four ratoons of bananas over the mother crop.

In conclusion, it is recommended to grow the introduced cultivars Williams Hybrid and Grand Nain in heavy clay soils and apply filter mud at the rate of 15% by volume at planting and apply nitrogen in the form of urea at 43 kg/ha at planting and then every four months thereafter.

Table 8. Interaction between cultivars and filter mud on the total yield of the mother, first, second and third ratoon crops of the three cultivars.

Cultivar	FM level (%)	Total yield (t/ha)			
		MC	FR crop	SR crop	TR crop
DC	0	18.9 cd	19.5 e	20.3 d	20.9 d
	15	20.5 c	22.7 d	23.5 c	23.7 c
	30	21.2 c	22.8 d	23.7 c	24.2 c
GN	0	27.0 b	28.6 c	29.8 b	30.5 b
	15	29.2 ab	30.4 b	31.4 ab	32.6 ab
	30	29.7 a	30.7 b	31.6 ab	32.7 ab
WH	0	28.9 ab	30.8 b	31.7 ab	32.9 ab
	15	30.3 a	32.7 a	33.2 a	33.7 a
	30	30.7 a	32.9 a	33.6 a	33.8 a
Sig. level		**	**	**	**

Means within columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.

* * indicate significance at P≤ 0.01 level.

DC=Dwarf Cavendish, GN=Grand Nain, WH=Williams Hybrid, FM=filter mud, MC=mother crop, FR=first ratoon, SR=second ratoon and TR=third ratoon.

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تأثير طينة المرشحات على نمو وإنتاجية ثلاثة أصناف من الموز المزروع في منطقة مشروع سكر كنانة، أواسط السودان

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الخلاصة

يعتبر الموز من المحاصيل المهمة في السودان وتتم زراعته في الأراضي الطميية حول الانهار. المواد العضوية لها مقدرة على تحسين الصفات الفيزيائية و الكيمائية للتربة و تزويد النبات بالمغذيات المعدنية. الهدف من هذا البحث هو تقييم أثر إضافة مستويين من طينة المرشحات 15% و30% بالحجم على النمو الخضري والإنتاجية للنبات الأم، و الخلفة الأولى و والثانية والثالثة لثلاثة أصناف من الموز. أجريت التجربة بمنطقة مشروع سكر كنانة، ولاية النيل الابيض في الفترة ما بين ديسمبر 2012 إلى نوفمبر 2014م، الأصناف المختارة هي الاصناف المستوردة هجين وليم و قراندنين و الصنف المحلى كافندش القزم . نظمت المعاملات بإستخدام القطع العشوائية الكاملة بأربع مكررات. بعد مرور ثلاثة أشهر من الزراعة ثم اختيار نباتين من كل حوض لقياس النمو الخضري والإنتاجية. أوضحت الدراسة وجود فروقات معنوية بين الأصناف في النمو الخضري ومكونات الانتاج والانتاج الكلى. الاصناف المستوردة اعطت افضل نمو خضري واعلى مكونات انتاج واعلى انتاج كلى بالمقارنة مع ما اعطاه الصنف المحلى الكافندش القزم ولكن الصنف المحلى كان ابكر من الاصناف المستوردة. اضافة طينة المرشحات بكلا المستويين اعطى معنويا افضل نمو خضري والى تبكير المحصول. كذلك اعطى زيادة معنوية في مكونات الانتاج والانتاج الكلى بالمقارنة مع الشاهد. يوصى بزراعة الاصناف المستوردة هجين الوليامز و قراندنين مع اضافة طينة المرشحات بمعدل 15% بالحجم للتربة الطينية.