

Response of Dwarf Cavendish Banana to Potassium Sulfate in Sennar Area

Abdalla Ahmed Mohamed Elhassan¹, Asim Fadl Abu-Sara¹,
Abbas Elsir¹ and Soud Mohamed Saad Eldin²

Abstract

Response of Dwarf Cavendish banana (*Musa spp.*) to potassium sulfate (K_2SO_4) fertilization was tested for two seasons (1997–98 and 1998–99) in banana orchard on the eastern bank of the Blue Nile in Sennar area ($13^\circ 37'N, -33^\circ 37' E$). This area assumes the greatest potential for banana production and known to be deficient in soil potassium. Treatments include six levels of potassium sulfate 0, 200, 400, 600, 800 and 1000 g/mat/year applied in two equal doses. Results indicated that the yield of the crop and the first ratoon can be fitted into a cubic regression model with a local maximum at the 400 g level. Nevertheless, economically, the 200 g level was proved more profitable than the 400 g one and hence it is requested for recommendation for banana fertilization in Sennar area.

Introduction

Banana is the popular fruit in Sudan and represents one of the most important cash crops. It is grown in many parts of the country, including Kassala State and along the banks of the Blue Nile. Sennar, in Central Sudan, is one of the most important areas of banana production for local consumption and export. This is because of the favorable climatic conditions, availability of irrigation water and the best infrastructure including the paved roads and transportation vehicles that facilitate crop movement to different parts of the country.

The banana plant, like most other plants, required 13 nutrient elements, some of them in big amounts due to its large leaf area and fast growth rate. In the current banana fertilization regimes, apart from nitrogen, most nutrients are neglected even if they are deficient in the soil and their visual deficiency symptoms are apparent. The effect of the disused nutrient elements may be reflected on banana growth, yield and quality.

In the Sudan, research on banana nutrition concentrated on fertilizers that supply nitrogen only and no research was conducted on potassium fertilizers, although its deficiency symptoms were observed in many parts of the country including Sennar area.

The present study was conducted, therefore, to evaluate the effects of six levels of potassium sulfate on the performance of the banana plant with the objective of elevating deficiency symptoms and boosting the economic yield of the crop in Sennar area.

¹ Gezira Research Station.

² Ministry of Agriculture, Gezira State

Materials and Methods

The study consisted of a pre-planting survey, soil analysis of the experimental site and a replicated field trial.

In May 1996 a formal non-stratified survey was conducted on banana orchards along the banks of the Blue Nile in Sennar area. The objective of the survey was to assess the magnitude of the banana nutritional problems with emphasis on potassium. Data collected include visual deficiency symptoms on leaves and fruits.

Based on the survey results, a trial was planned and executed to evaluate the effect of potassium nutrition on banana growth and yield. The experiment was carried out in a private orchard, 14 km north Sennar Dam, on the eastern bank of the Blue Nile for two seasons (1997–98 and 1998–99). Pre-planting soil samples were collected from auger pits, 0 – 30 and 30 – 60 cm in depths, for site characterization. The farm was previously planted to citrus for 18 years with occasional fertilization with urea and/or animal manure.

Banana was planted on 15 June 1997 at spacing of 3 x 3 m (1111 plants/ ha). A randomized complete block design with 5 replications was used and two plants represent the experimental plot. Cultural practices included shallow hand hoeing every two weeks, irrigation every 7 – 10 days in winter, 5 – 8 days in summer and when required during the rainy season. Each experimental plot received 300 g urea (46% nitrogen) per annum split-applied into 4 doses at intervals of three months.

A period of three months was allowed to pass before a sucker was permitted to grow to form the first ratoon crop. At the six months stage another sucker was allowed to shoot out as the 2nd ratoon. Thus when the mother plant started to mature it had only two suckers. After harvest the mother plant was removed and the first ratoon leads the growth for the next generation and so on.

Forked poles (propping) were used whenever needed to support the bearing plants from falling down as a result of the bunch weight and/or the winds.

Treatments included 0, 200, 400, 600, 800 and 1000 g potassium sulfate (42% K + 17 % S) per mat per annum split-applied into two doses. For the mother crop the first dose was applied three months after planting and the second one after six months, while for the ratoons it was applied every six months. The fertilizer was placed around the pseudostem 30 cm apart from the plant, and the plots were irrigated immediately.

Data was collected for the mother plant and the first ratoon and included plant height, pseudostem diameter (girth), number of leaves, days from planting to shooting and from shooting to harvesting, yield and yield components.

Results and Discussion

The survey results indicated a predominant occurrence of leaves with dry irregular chlorotic surfaces and dry scorched edges combined by premature yellowing of undersize fruits. These are the typical symptoms of potassium deficiency in banana as described by Brady and Weil (2000).

Soil analysis revealed that the experimental site is non-saline, non-sodic and with good physical characteristics (Table 1). The nitrogen level (610 – 620 ppm) is relatively high compared to the standard level in Sudan. This might have resulted from

the decomposition of leaf litters (Naiem, 1998) and/or the residual fertilizers applied to the previous crop (citrus). The site is deficient in potassium ($K < 250$ ppm) and of low Zn level (1.32 – 1.61 ppm) according to the standards of Metson (1961), Cox and Kamprath (1972) and Lichthardt and Jacobsen (1998). The low potassium level might have been resulted from the continuous removal by cropping without replacement as suggested by Elhassan (2002). The low Zn might be due to the high pH value (Brady and Weil, 2000).

Table 2 shows the effect of potassium sulfate on yield and yield component of the banana mother and first ratoon crops, while Figures 1 and 2, depict the yield response of the two crops in the same order to the levels of the added fertilizer. Significant yield differences were detected for the mother ($p=5\%$) and the ratoon ($p=1\%$) crops, with the fertilized treatments out yielded the control in both. Differences for yield components as measured by number of hands and figures per bunch or finger length and width were not significant at $p = 5\%$. The cumulative effects of these components might have resulted in the observed yield differences.

The yield response of the mother and the ratoon crop was best fitted to a third degree polynomial curve with a local maximum at 400 g potassium sulfate (Figs. 1 and 2). The cubic equations accounted for 94.2 and 88.5% of the observed variances for the mother and the first ratoon crops, respectively. This means that 400 grams K_2SO_4 /mat/year is enough to obtain the maximum banana yield and can correct the potassium deficiency at Sennar. This is consistent with the results of Yadav and Singh (1988) and Brady and Weil (2000).

Potassium sulfate contains 17% sulphur that might have caused a temporary reduction in soil pH of the rizosphere. Roemheld (1983) reported that lowering of the pH in alkaline soils improves the availability of nutrients such as Zn, Mn, P, Fe and B. This may explain part of the increase in banana yield observed in this trial.

The effect of potassium sulfate on growth parameter of banana crop and first ratoon is shown in Table 3. No significant differences ($p= 5\%$) were observed for plant height, pseudostem diameter and number of leaves. In contrast Osborne and Hewitt (1963) reported that potassium increase the growth of banana pseudostem.

Potassium sulfate at the higher levels (800 and 1000 g/mat/year) significantly shortened the period from planting to shooting; however, this was not reflected in early harvesting (Table 3).

Dominance, partial budget and marginal rate of returns analysis, as described by CIMMYT (1988), were used to evaluate the profitability of the different potassium sulfate treatments. Recent prices, from the 2005 season, were used for these analyses. Dominance analysis (Table 4) indicates that the significant yield advantage obtained by increasing potassium sulfate application from 200 to 400 g does not compensate for by the additional cost of the fertilizer. Therefore, the 200 g treatment dominated the 400 g treatment as it produced higher net returns at a lower cost. Table 5 indicates that application of 200 g potassium sulfate is very profitable as represented by the high MRR. For each SD invested in application of the fertilizer the farmer will get that SD plus 407 extra SDs.

The results of the study conclude that addition of 200 g potassium sulfate per mat per ear (equivalent to 222 kg/ha) is the most economically viable fertilizer level for banana production in Sennar area. High yield advantage and higher rate of return were realized for both the mother and the first ratoon crops.

Recommendations

Based on the foregoing discussion, the authors request the Crop Husbandry Committee to recommend the following: Annual application of 200 g potassium sulfate per mat per annum (equivalent to 222 kg/ha) in two equal doses to banana grown in Sennar area. The first dose 3 months after planting and, hence, one dose after each 6 months.

References

- Brady, N.C. and Weil, R.R (2000). Elements of the Nature and Properties of Soils. 12th edition. Prentice-Hall Inc p. 560.
- CIMMYT (1988). From Agronomic Data to Farmer Recommendations. An Economic Training Manual. Completely Revised Edition Mexico, D.F.
- Cox, F.R. and Kamprath, E.J. (1972). Micronutrients in soil tests. In "Micronutrients in Agriculture" pp 289- 317. Martvedt .J. et al (eds). Soil Sci. Soc. Am. Madison, Wisconsin.
- Elhassan, A.A.M. (2002). Changes of some physical and chemical properties of soil under recent and old citrus orchards and response of citrus trees to nitrogen fertilization. PhD thesis, University of Khartoum.
- Lichthardt, J.J and Jacobsen, J.S. (1998). Critical Soil Test Levels. Montana MSU Extension Service Bulletin EB104.
- Metson, A.J. (1961). Methods of chemical analysis for soil survey samples. New Zealand DSIR Soil Bur Bull 12. Govt printer. Wellington, New Zealand.
- Naeim, A.A. (1998). Organic fertilization in Sudan. 1st colloquium, Land and Water Research Center, Agric. Res. Corporation, Wadmedani, Sudan pp 125-132.
- Osborne, R.E. and Hewitt, C.W. (1963). The effect of frequency of nitrogen, phosphate and potash on Lacatan banana in Jamaica. Trop Agric. 40:1-8.
- Roemheld, V. (1983). pH changes in the rhizosphere depending on nutrients supply. Landwirtschaftliche Forschung 36, Sonderheft 40: 226 - 230.
- Yadav, I.S. and Singh, H P. (1988). Response of banana to different levels and frequency of potassium application. South India Horticulture 36(24):167-171.

Table 1. Soil characteristics of the experimental site, East Sennar (1997)

Character	0 - 30cm	30 - 60cm
Sand %	57	64
Silt %	19	13
Clay %	24	23
Texture class name	Sandy clay loam	
pH (paste)	7.3	7.3
ECe dSm⁻¹	0.49	0.72
SAR	0.23	0.20
Total N %	0.061	0.062
Available P ppm	1.90	1.23
Soluble K mg/kg	51	7.0
~ Ca mg/kg	66	130
~ Mg mg/kg	40	44
~ Na mg/kg	11	10
EDTA Extractable		
~ Zn ppm	1.61	1.32
~ Fe ppm	14.6	21.5
~ Mn ppm	6.53	6.54
HCO₃⁻	meq/L	
	5.33	5.17
CL⁻	~	2.83
SO₄⁼	~	2.93

Table 2. Effect of potassium sulfate fertilization on yield and yield components of banana mother plant and first ratoon crop in Sennar area.

Potassium sulfate level (g/mat)	Total Yield (ton/ ha)	Hands per bunch (No.)	Fingers per bunch (No.)	Finger length (cm)	Finger diameter (cm)
<i>Mother Crop</i>					
0	22.8 b	6.4	10.4	14.3	2.1
200	28.7 a	7.6	10.8	14.8	2.6
400	29.7 a	7.8	11.8	14.2	2.4
600	27.2 a	7.8	12.0	15.2	2.7
800	26.9 ab	7.1	12.0	14.2	2.8
1000	27.9 a	7.5	11.7	14.4	2.5
Significance level	*	NS	NS	NS	NS
SE (±)	2.12	1.07	2.4	1.69	0.34
CV (%)	8.65	14.5	20.9	11.66	13.5
<i>Ratoon Crop</i>					
0	22.8 b	7.0	10.5	14.4	2.3
200	27.2 a	8.6	11.4	13.6	2.7
400	27.8 a	9.1	12.1	14.6	3.0
600	25.4 ab	8.8	12.6	14.8	2.8
800	26.4 a	9.1	12.3	14.6	2.9
1000	28.6 a	8.9	12.8	14.8	2.6
Significance level	**	NS	NS	NS	NS
SE (±)	2.44	1.0	2.59	2.28	0.26
CV (%)	9.24	12.15	21.58	15.87	9.56

Total yield calculated on the bases of whole bunch weight (hands + stalk) /plant.

*,**= Significantly different at 5% and 1% probability levels, respectively.

NS= Not significantly different at p = 5% level.

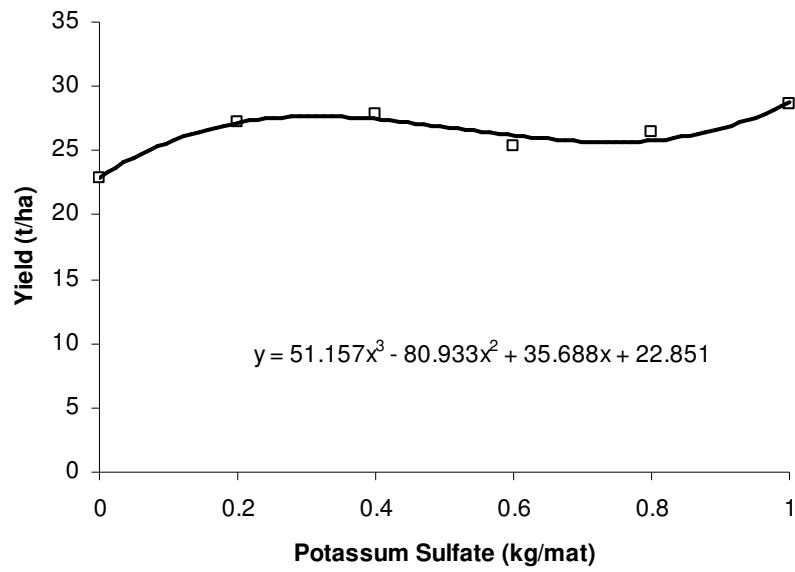


Figure 1. Response curve of banana crop yield to potassium sulfate fertilization at Sennar area

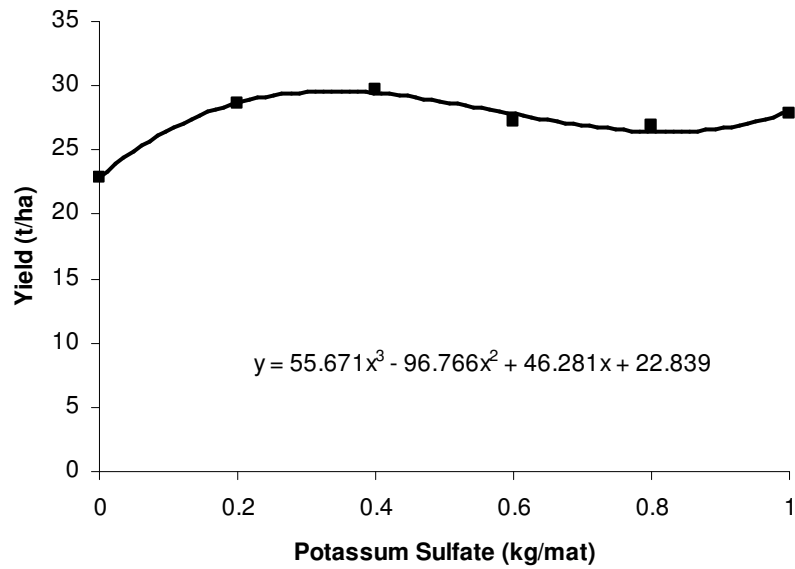


Figure 2. Response curve of banana ratoon yield to potassium sulfate fertilization at Sennar area.

Table 3. Growth parameters, days to flower shooting and harvesting of banana plant and the first ratoon crops at affected by potassium sulfate fertilization.

Potassium sulfate level (g/mat)	Plant height (cm)	Pseudostem diameter (cm)	No of leaves	Days to Shooting	Days to Harvesting
<i>Mother Crop</i>					
0	127	60.3	13.9	453 a	94.4
200	130	60.6	13.5	456 a	93.2
400	129	61.8	14.5	450 a	93.6
600	129	57.4	14.2	450 a	92.8
800	129	60.0	13.9	445 b	92.2
1000	125	56.6	14.0	443 b	91.2
Significance level	NS	NS	NS	**	NS
SE (±)	12.4	6.52	1.0	1.65	1.23
CV (%)	9.7	10.9	7.1	0.37	1.33
<i>Ratoon Crop</i>					
0	127	63.2	13.8	547 a	95.4
200	129	62.9	13.8	544 a	94.8
400	131	63.9	13.9	544 a	95.4
600	128	59.5	14.0	544 a	94.4
800	130	62.1	13.4	539 b	93.6
1000	125	58.7	14.4	537 b	92.4
Significance level	NS	NS	NS	**	NS
SE (±)	11.2	3.5	0.69	1.65	1.1
CV (%)	8.74	5.7	5.0	0.3	1.2

*,**= Significantly different at 5% and 1% probability levels, respectively.
 NS= Not significantly different at p = 5% level.

Table 4. Partial Budget and dominance analyses of the effect of potassium sulfate fertilizer on banana Production in Sennar State

Potassium sulfate (gm/plant)	Potassium sulfate (kg/ha)	Total yield (ton/ha)	Gross return (SDha)	Variable cost (SD/ha)	Net return (SD/ha)	Dominance
0	0	22.79	797,650	-	797,650	
200	222	27.94	977,900	35,567	942,333	
400	445	28.74	1,005,900	71,133	834,767	D
600	667	26.32	921,025	106,700	814,325	D
800	889	26.65	932,750	142,267	790,483	D
1000	1111	28.25	988,750	177,834	810,916	D

Table 5. Marginal Analysis of Potassium Sulfate fertilizer on Banana production in Sennar State

Potassium sulfate (gm/plant)	Total yield (ton/ha)	Variable cost	Net return	Marginal cost	MRR
0	22.9	-	797,650	-	-
200	27.9	35,567	942,333	144,683	406,79