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Response of Banana "Williams Hybrid" to Nitrogen، Phosphorus and Potassium Fertilization

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ABSTRACT

Field experiments were conducted at the National Institute for Promotion of Horticultural Exports (NIPHE) research farm during the period of 2001 to 2002 to determine the effects of nitrogen, phosphorus and potassium levels on growth parameters, earliness, nutrient uptake، yield and yield components of "William's hybrid" banana cultivar. Treatments included 5 N levels (0, 69, 138, 207 and 276g N/mat/year), 2 P levels (0 and 20 g P/mat/year) and 2 K levels (0 and 41 g K/mat/year). The treatments were arranged in a randomized complete block design with 3 replications. Banana growth, yield and yield components were significantly increased by N and K application. The highest vegetative growth parameters, yield and yield components were obtained with the application of 207 g N/mat/year in combination with 41 g K/mat/year. Application of N in combination with K also resulted in a significant reduction in the period from plant-ing to shooting and from shooting to fruit maturation. The shortest number of days to shooting were obtained with the application of 276 g N/mat/year. Application of N, P and K also resulted in increased leaf N, P and K contents. Application of P alone or in combinations with N and K had no significant effects on growth or yield parameters.

INTRODUCTION

Banana cultural practices in Sudan have received little attention and a lot of information is required in this area to increase banana yields. Most of Sudanese banana growers do not appreciate the importance of banana fertilization and its contribution to high yields (Eltahir and Hassan، (1997).

Nitrogen has been reported to have a positive effect on banana growth, dry matter content, maturation period, yield and quality (Twyfords, 1967؛ Gowen,1995 and Arunachalam *et al*, 1976). Dawood *et al*. (1999) studied the performance of Dwarf Cavendish banana cultivar grown on heavy clay soils and found that maximum yields were obtained with the application of 153 kg N/ha/year.

Potassium has been reported to be the most important element in banana nutrition(Geus,1973).A fully' grown plant contains more potassium than all other minerals combined. Potassium uptake has been found to be greater during vegetative growth than during fruit maturation (Robinson, 1996). Mustafa (1988) reported that potassium application resulted in an increase in plant height, pseudostem girth, bunch weight and total yields.

Considering the available information on banana fertilization so far, more research work is needed to study the effects of different nutrients and their levels on banana production. Therefore. the objective of this study was to evaluate the effects of different levels of N, P and K on growth and yield of banana.

MATERIALS AND METHODS

Field experiments were conducted at the National Institute for the Promotion of Horticultural Exports (NIPHE) research farm at Hantoub on the east bank of the Blue Nile, (lat. 14.5^0N, and long. 33.4^0E) during the period from 2001 to 2002. The area lies within an arid climate of summer rains and relatively warm winter. The mean minimum temperature is 14 ^{0}C in January and the mean maximum temperature is 43^0C in May. Average annual rainfall is 320 mm, however, the total annual rainfall varies from year to year. The rainy season lasts from June to October, with a well-defined peak in August. Humidity is generally low with a peak of 60% in August and decreases to its lowest value of about 10% in April.

The soil at the experimental site is classified as fine, smectitic, isohyperthermic, Typic Haplpcambids (Soil Survey Staff, 1999). Surface soil samples (0-30 cm) were taken before conducting the experiment to determine some physical and chemical properties of the soil. The soil contains 51% clay, 27% fine sand and 20% silt with a pH of 8.0. 0.036% total N, 14.6 mg/kg available P and 0.37% organic carbon. Suckers of

cultivar Williams Hybrid were planted in 30 x 30 x 30 cm pits at spacing of 3 x 3m. Plot size was 6 x 6m. Fertilizer treat-ments consist of five N levels (0, 69.138, 207 and 276g N/mat/year), two P levels and 20g P/mat/year) and two K levels (0 and 41g K/mat/year). Nitrogen applied in the form of urea in a ring around the pseudostem in four equal split doses. The first dose was applied planting and the other three doses were applied every 3 months. Phosphorus and potassium were applied in one dose in the pit at planting in the form of triple superphosphate and potassium sulphate. respectively. Treatments were arranged in a randomized complete block design with three replications. Irrigation and weed control were applied as required.

Three months after planting, two plants from each plot were randomly selected, tagged and used for growth measurernents. Number of leaves, leaf area, plant height and pseudostem girth were recorded at monthly intervals. Leaf area was calculated as the product of length and width times a factor of 0.8 as described by Murray (1959). Plant height measured at shooting at 5 cm above the ground level up to the point of intersection of the bunch stem and the young-est leaf. Pseudostem girth was measured at 5 cm above the ground level.

At shooting time, the third youngest fully-open leaf was taken for leaf analysis. The mid area of the lamina on both sides of the midrib (15 x15 cm) was used for determination of nitrogen. phosphorus and potassium contents. Leaf samples were washed using distilled water, kept in paper bags. and then dried in an air-forced oven at 70^0C for 48 hours. The samples were then ground in a Willey mill to pass through a 40-mesh screen. Total nitrogen was determined using macro- Kjeldahl method (Trandon phosphorus was determined using the vandate-molybdate method(Tandon, 1993). and potassium was determined using a flame photometer after dry ashing at 500^0C.

The number of days from planting to shooting and from shooting to harvesting were recorded. Bunches were harvested when fruits were at the mature green, "full three quarters" stage. Bunches were weighed and then dehanded. Hands and stalk were separately weighed. The number of hands and fingers per bunch were counted.

MSTATC computer program was used for the analysis of variance and regression analysis. Mean separation was done according to Duncan's Multiple Range Test.

RESULT'S AND DISCUSSION

Vegetative growth

The effects of N and K on vegetative growth parameters of banana Plants are shown in Table l. Application of N resulted in highly significant linear and quadratic effects on plant height, pseudostem girth area and number of leaves per plant. These parameters increased as increased up to 207 g/mat/year, however. they decreased as N rate
increased to 276 g/mat/year. Application of K at 41g/mat/year also resulted in a highly significant increase in plant height. pseudostem girth, leaf and number of leaves per plant as compared to the control.

The main effects of P on plant growth parameters were not significant.

Table l. Banana vegetative growth as influenced by K and N fertilizers.

Fertilizer rates(g/mat/year) N	K	Plant height (cm)	Pseudostem girth (cm)	Leaf Area(m^2)	Number of leaves
	0	128.33 f	41.25 h	0.81 e	12.75 e
	69	141.75 de	42.75 fg	0.93 d	14.08 d
	138	143.00 cd	43.58 def	0.95 c	14.75 cd
	207	142.19 cde	43.92 de	0.96 ab	15.68 ab
	276	141.00e	42.67 g	0.87 c	15.08 bc
	0	144.75 cd	43.17 efg	0.97 ab	15.42 bc
	69	153.00 b	45.08 c	0.96 ab	15.67 ab
	138	157.83 a	46.00 b	0.98 ab	15.92 ab
	207	159.91 a	47.00 a	I .00 a	16.42 a
	276	145.91c	44.17 d	0.97 ab	
F test significances					
P		NS	NS	NS	NS
K		**	**	**	**
N Linear		**	**	NS	**
N Quadratic		**	**	NS	**
N x Kinteraction		*	*	**	**

***and NS indicate significance at $P \leq 0.05$, 0.01 and not significant, respectively. Means within each column followed by the same letters are not significantly different according to Duncan's Multiple Range Test.

The interaction effects of N and K on vegetative growth parameters Were significant. The highest values of plant height, pseudostem girth، leaf and number of leaves per plant were obtained with the application of N at the rate of 207g/mat/year in combination with 41g K/mat/year. There were no additional increases in vegetative growth
parameters as a result of further increases in N rate or application of P in combination with N and K. These results are in agreement with those reported by Dawood *el al*. (1999) who showed significantly higher values of growth parameters in "Dwarf Cavendish" banana cultivar as a N fertilization. Baruah and Mahanta (1997) reported that the a of 200g N/mat/year in four doses resulted in the tallest banana plants with the biggest pseudostem girth, the highest leaf area and functional leaves as compared with the control. Mustafa (1988), working on "Hill" banana plants, found a significant increase in plant height and pseudostem diameter as a result of the application of K fertilizer Similarly, Eltahir and Hassan (1997) reported a great increase in banana growth as a result of foliar application of K. Our results showed no significant increase in banana growth with the application of P. Likewise Geus (1973) and Robinson (1996) found that banana requirement for P was not so great as compared with that of N and K, and P deficiency symptoms were rarely seen in most banana growing areas. Soil P content at the experimental site is probably adequate to sustain banana growth.

Crop earliness

The main effects of N on banana crop earliness are shown in Table 2. There was a highly significant linear effect on number of shooting and both a linear and quadratic effects on number of days from shooting to harvesting. Both number of days to shooting and number of days from shooting to harvesting decreased up to 207g N/mat/year. However, number of days from shooting to harvesting increased with further increases in N rate. Banana plants receiving 207g N/mat/year were 31 days earlier to shooting and they matured a week earlier than the control. These findings are in agreement with those reported by Oliveira (1999) who showed that increased N rates significantly reduced the time to bunch shooting and from bunch shooting to harvesting.

Table 2. Main effects of N on banana crop earliness and N content of leaves

N rate (g/mat/year)	No. of day to shooting	No. of day from shooting to harvesting	N content of leaves (%)
0	265	121	2.68
69	245	117	3.47
138	235	116	3.64
207	234	115	3.71
276	227	121	3.79
F test significances Linear	**	**	**
Quadratic	NS	**	NS

**and NS indicate significance at P 0.01 and not significant, respectively.

The interaction effects of N and K on number of days from planting to shooting are significant (Table 3). Application of N at the rate of 276 g/mat/year in combination with 41 g K/mat/year resulted in the shortest period from planting to shooting and hence crop earliness. These combinations of N and K resulted in the production of a banana crop 51 days earlier than the untreated control. Arunachalam *et al*. (1976). and Oliveira (1999) reported that the period of time from planting to bunch emergence was significantly reduced by N application. Also, Eltahir and Hassan (1997) reported that K tended to stimulate early inflorescence, faster maturity of banana bunches and hence early harvest of the crop. Application of P in combination with N or K had no significant effects on crop earliness.

Mineral nutrient uptake

The main effects of N fertilizer on N content of banana leaves at shooting are shown in Table 2. There was a, highly significant linear effect of N rates on the N content of leaves. A similar trend was observed by Dawood *et al*. (1999) in "Dwarf Cavendish" banana, who reported that increasing N rates resulted in increasing levels of leaf N content. They found that the optimum N rate was 138g N/mat/year, which corresponded to a leaf lamina N content of 3.3%. Our results indicated that the optimull) N rate for "Williams hybrid" banana was 207 g N/mat/year which corresponded to a leaf lamina N content of 3.71.%

Table 3. Interaction effects of K and N on number of days from planting to shooting.

Fertilizer rates (g/mat/year)		Number of days to shooting
K	N	
0	0	276 a
	69	252 b
	138	241 c
	207	238 d
	276	229 e
41	0	253 b
	69	238 d
	138	228 e
	207	228 e
	276	225 f
Significance level		*
C.V.(%)		3.3
SE(+)		2.3

*indicates significance at P≤ 0.05

Means within each column followed by the same letter(s) are not significantly different according to Multiple Range Test.

The effects of K and P fertilizers on banana leaf K and P contents at shooting are shown in Table 4. Application of K and P separately or in combination resulted in a significant increase in K and P contents of leaves. A similar trend reported by Eltahir and Hassan (1999) who found that application of foliar K resulted in a significant increase in the K content of leaves. [he critical concentration of K in banana was reported to range from 3.0% to 3.50/0 (Mustafa. 1988). Our results showed that the concentration of K in the leaves of banana plants which received K fertilizer was 4.2% or higher.

Yield and yield components

The effect of N and K on Yield and yield components are showed in Table 5. Application of N resulted in a highly significant linear and quadratic effects on bunch eight. number of fingers per bunch and total yield. The highest values of yield parameters were obtained with the application of 207g N/mat/year. However, an increase in N rate to 276g mat/year resulted in a decrease in yield parameters. Banana yield increased

from 16.58 ton/ha in plants that did not receive N to 24.39 ton/ha in plants which received 207g N/mat/year. A similar trend was obtained by Dawood *et al* (1999) who reported an increase in banana yield with an increase in N rates. and maximum yields of banana obtained with the application of N at the rate of 1382/mat/year. Hedge (1988) reported a significant increase in yield of "Robsuta" banana when N rate was increased from 100 to 200g N/plant. Warner and Fox (1977). working on "Willian's Hybrid•• banana reported that maximum yields were obtained with the application of 161kg N/ha/year. The effect of K on yield parameters was also highly significant. Yield components significantly increased with the application of K al the rate of 41 g/mat/year. Mustafa (1988) and Eltahir and I Hassan (1997) reported that application of K resulted in significant increases in bunch and total yields of bananas. The effect of P on yield components not significant.

Table 4. Effects of K and P fertilizers on P and K contents of banana leaves at shooting.

Fertilizer rates(g/mat/year)		P	K
K	P	% dry weight	
0	0	0.09 b	3.80 b
	20	0.12 a	3.70 b
	0	0.08 b	4.30 a
	20	0.14 a	4.20 a
Significance level		*	*
C.V.(%)		12.68	7.71
SE(+)		0.003	0.08

*indicates. significance at $P \geq 0.05$ Means within each column followed by the same letter(s) are not significantly according to Duncan's Multiple Range Test.

The interaction effects of N and K on yield and yield components are significant. The highest bunch weight. number of hands per bunch. number of fingers per bunch and total yield were obtained with the application of 207 g N/mat/year in combination with 41 g K/mat/year.

In conclusion. our results indicated that the highest yield and yield components were obtained by the fertilization of bananas with N at the rate of 2()7 g N/mat/year applied in four split doses in combination with 41g K/mat/year applied at planting.

Table 5. Yield and yield components as influenced by K and N fertilizers

Fertilizer rates (g/mat/year) K	N	Bunch Weight (kg)	No. of fingers/bunch	No. of hands/bunch	Total yield (ton/ha)
0	0	13.69 g	112.11 h	8.08 ab	15.23 g
	69	18.43 d	126.37 e	8.00 b	20.61 d
	138	19.62 c	136.25 d	8.17 ab	21.79c
	207	21.49b	139.75 c	8.50 a	23.90 b
	276	16.40 f	120.38 g	7.92 C	18.22 f
40	o	16.16 f	1 14.00 h	7.92 c	17.95 f
	69	19.33 c	135.67 d	8.50 a	21.84 c
	138	19.54 c	142.92 b	8.00 b	21.70 c
	207	22.40 a	154.33 a	8.00 b	24.88 a
	276	17.29 e	123.92 f	8.42 a	19.21 e
F test significances K		**	**	NS	
N Linear		**	**	NS	**
N Quadratic		**	**	NS	**
Nx K interaction		**	**	*	**

** *and NS indicate significance at 1)60.05, 0.01 and not significant, respectively.
Means within each column followed by the same letter(s) are not significantly different according to Duncan's Multiple Range Test.

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