Effect of plant spacing and number of suckers on yield components and fruit quality of the plant crop and the first four ratoons of banana clones in central Sudan

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ABSTRACT

Experiments were carried out at the research farm of the National Institute for the Promotion of Horticultural Exports (NIPHE), University of Gezira, Wad Madani, Sudan, during the period from January 2001 to April 2004 to study the effects of plant spacing and number of suckers on crop cycles, yield and fruit quality of the plant crop and the first four ratoons of introduced banana clones, namely William's Hybrid 172 (WH) and Grand Nain 1824 (GN) in comparison with the local clone Dwarf Cavendish (DC). Plant spacing was 2x2 m, 2x3 m and 3x3 m. The selected suckers were 2, 3, or 4 around the mother plant. Treatments were arranged in a split-split plot design with three replications. The introduced clones GN and WH produced significantly higher bunch weight, total and exportable yields and longer fruit green life, but lower total soluble solids (TSS) content than the local clone DC in the plant crop and ratoons. Plant spacing of 3x3 m resulted in the highest bunch weight and exportable yield, but it gave the lowest total yield in both the plant crop and ratoons as compared to the close spacing of 2x2 m. Also, the wide spacing resulted in significantly shorter crop cycles, longer fruit green life and higher TSS content than the close spacing. Keeping two suckers per mat resulted in the highest bunch weight and the highest exportable and total yields in the plant crop and ratoons, but longer crop cycles. However, keeping four suckers per mat produced the lowest total and exportable yields, but resulted in shorter crop cycles.

INTRODUCTION

Banana is one of the most popular and widely consumed fruits for of its low price and availability all year round. The predominant cultivar grown in Sudan is the Dwarf Cavendish which is very popular in the local market. However, this cultivar cannot compete in international markets due to its small fingers and high perishability (Hamed, 1992).

The National Institute for the Promotion of Horticultural Exports has introduced several clones including William's Hybrid 172 (WH) and Grand Nain 1824 (GN), which are widely accepted in the world trade. These clones were evaluated in comparison with the local cultivar Dwarf Cavendish (DC). These clones were reported to be superior in vegetative growth and yield components compared to local Dwarf Cavendish (Mahmoud and Elkashif, 2003; Elsiddig, 2003).

Spacing of banana plants is an important cultural practice because it determines plant population and hence the number of bunches per unit area. Therefore, the most appropriate plant density should be chosen depending on cultivar, soil type and management. Generally, a wide spacing (3x3 m) results in vigorous vegetative growth, heavy bunches, large fingers and high exportable yield, whereas close spacing results in high total yield but low exportable yield due to small-sized fruits (Elsiddig *et al.*, 2009).

Banana plant spacing also affects the time from planting to harvesting and hence crop earliness. Generally, wider plant spacing results in a shorter period from planting to harvesting and *vice versa*. In most banana clones, the period from planting to harvesting ranges from 360 to 450 days (Robinson, 1996). The introduced clones took a longer time from planting to harvesting than the local Dwarf Cavendish (Mohamed, 2003). Management of suckers in a banana plantation is an important cultural practice because it affects crop cycle, yield and fruit quality. Selection of the appropriate number of suckers is based on their age, size and location in the mat to prolong the life span of the plantation. Surplus suckers are regularly removed from the mat so as not to compete with the mother plant and follower suckers for assimilates (Robinson, 1996). Sucker management should strike a balance between high yield and large-sized exportable fruits. Usually, two, three or four suckers are selected per mat depending on soil fertility and cultural practices.

In a pervious study, plant spacing and number of suckers effects on vegetative growth, yield components and fruit quality of the plant crop of 'William's Hybrid 172 (WH), Grand Nain 1824 (GN) and Dwarf Cavendish (DC)' banana were evaluated (Mahmoud *et al.*, 2010). The objective of this work was to determine the effect of plant spacing and number of suckers on yield components, crop cycles and fruit quality of the plant crop and first four ratoons of the introduced banana clones (WH and GN) as compared to the local clone (DC).

MATERIALS AND METHODS

This study was carried out at the National Institute for the Promotion of Horticultural Exports (NIPHE) research farm at Hantoub area, along the eastern bank of the Blue Nile, lat.19.5 N, long.33.4 E, during the period from January 2001 to April 2004. The area lies within an arid climate of hot summer and relatively cool winter.

The banana clones 'William's Hybrid 172' (WH) and 'Grand Nain 1824' (GN) were introduced from Vienna, Austria and compared with the local cultivar 'Dwarf Cavendish' (DC).

Uniform, healthy sword suckers, 4-6 months old were planted in pits 40×40×40 cm at the spacings of 2×2 m, 2×3 m and 3×3 m. Two, three or four suckers at different ages were selected around the mother plant at each spacing and for all clones. Surplus suckers were removed as soon as they appeared at the ground level. The treatments were arranged in a split-split plot design with three replications. Spacing was the main plot, clones were the sub-plots and number of suckers per mat were the sub-sub-plots. The cultural practices were carried out as recommended (Hamed, 1992).

Yield and crop earliness

After bunch shooting, the number of days from planting to shooting and from shooting to harvesting were determined for the main crop, first, second, third and fourth ratoons. For the determination of the crop cycles, the number of months from harvesting the plant crop to harvesting the first ratoon, first to second ratoon, second to third and third to fourth ratoon were recorded. Also, the number of months from planting to harvesting the fourth ratoon was recorded.

Bunches were harvested at the full three quarter stage, weighed and total and cumulative yields were determined. Cumulative yield was the summation of the yield of the plant crop and that of the first four ratoons. Then they were dehanded and exportable hands were selected according to the length of the middle finger of the outer whorl of each hand. Finger lengths equal to or more than 20.3 cm were considered exportable. Exportable yield (%) was calculated as follows:

$$\text{Exportable yield (\%)} = \frac{\text{Weight of exportable hands}}{\text{Total weight of hands}} \times 100$$

Fruit quality

Green life, which is the number of days from harvest till the fruits start to change from dark green to light green colour, was determined. The hands were washed with water to remove latex and dust. A solution of commercial bleach (Chlorox) of 5.25 % sodium hypochlorite at a concentration of 125 ppm was used as a disinfectant. Fruits were placed in polyethylene bags in a cold room calibrated at 14^0C. At the end of the green life and when banana fingers started to turn yellowish green in colour, they were dipped in Ethrel solution at a concentration of 2 ml l^{-1} and ripened at 20^0C (John and Marchal, 1995).

Total soluble solids (TSS) of ripe fruits were measured according to the procedure of Dadzie and Orchard (1997). Thirty grams of the pulp were blended with 90 ml distilled water for two minutes and TSS of the extracts were measured using a hand refractometer (model HRN-32).

The data were subjected to analysis of variance and means were separated using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The main effects of banana clones, plant spacing and number of suckers on bunch weight, total and exportable yields were significant (Table 1). The clone WH resulted in the highest bunch weight, total and exportable yields, followed by GN, whereas DC resulted in the lowest values. These results confirm pervious findings (Mahmoud and Elkashif, 2003; Mohamed, 2003). Generally, yield components increased gradually from the plant crop and reached their peak in the second ratoon and then decreased towards the third and fourth ratoons. Similar results were reported by Mohamed (2003).

The effects of plant spacing on yield components were highly significant (Table 1). Plant spacing of 3x3 m resulted in the heaviest bunches and highest exportable yield, but it gave the lowest total yield. However, the close spacing (2x2 m) resulted in the smallest bunches, the lowest exportable yield and the highest total yield. This was true for the plant crop and ratoons and followed the same trend mentioned earlier. Robinson and Nel (1988) reported that high plant densities resulted in progressively low yields as the plantation ages and a consequent reduction in the economic life span of the plantation. Our results are consistent with those reported by Elsiddig *et al.* (2009). The heavy bunches and large exportable yield produced at the wider spacing (3x3 m) was mostly due to the low competition between plants for water and mineral nutrients as compared to the closer spacing (2x2 m). Nevertheless, the high yield produced at the closer spacing was due to the large number of bunches produced per unit area, but mostly of small non-exportable fruits.

The effect of number of suckers on yield components were significant for the plant crop and ratoons (Table 1). The lowest number of suckers resulted in the heaviest bunches and the highest exportable and total yields in the plant crop and ratoons, and the opposite was true for the largest number of suckers. This was most probably due to the less competition
between plants in the same mat encountered at the low number of suckers and the reverse was true. In order to strike a balance between total and exportable yields, it seems that three suckers per mat were most suitable. The interaction effects of banana clones and plant spacing on yield components of the plant crop and ratoons were significant (Table 2). The introduced clones GN and WH grown at the closer spacing (2x2 m) produced the highest total yield but the lowest exportable yield and the opposite was true with the wider spacing (3x3 m). The local clone DC recorded the lowest yield values as compared to the introduced clones. These results are in agreement with those reported by Elsiddig *et al.* (2009).

Table 1. Main effects of banana clone, plant spacing and number of suckers on yield components of the plant crop and rations.

Clones	Bunch weight (kg)					
	PC	R_1	R_2	R_3	R_4	Av.
DC	14.3 c	15.7 b	15.4 b	14.4 c	13.3 b	14.6 c
GN	16.7 b	19.1 a	19.9 a	16.0 b	14.3 b	16.8 b
WH	18.8 a	20.5 a	20.5 a	19.8 a	16.3 a	19.2 a
Sig.	**	*	**	*	*	
Plant spacing (m)						
2 x 2	14.9 b	14.6 b	12.2 b	9.9 b	8.6 b	12.0 b
2 x 3	16.2 a	19.2 a	19.6 a	18.5 a	17.5 a	18.2 a
3 x 3	16.9 a	19.8 a	20.7 a	19.3 a	18.0 a	18.9 a
Sig.	**	***	***	***	***	
No. of suckers						
2	16.6 a	19.8 a	18.4 a	18.0 a	17.0 a	18.0 a
3	15.3 b	18.3 b	17.0 b	16.7 b	13.7 b	16.2 b
4	13.0 c	17.8 b	15.1 c	14.8 c	13.3 b	14.8 c
Sig.	**	**	*	***	***	**

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.
*,** and *** indicate significance at $P \leq$ 5%, 1% and 0.1%, respectively.
PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

Table 1. Continued.

Clones	Exportable yield (%)					
	PC	R_1	R_2	R_3	R_4	Av.
DC	36.0 b	33.7 b	36.4 b	29.7 c	26.1 b	32.4 c
GN	47.1 a	49.2 a	50.9 a	47.7 ab	42.4 a	47.5 b
WH	47.9 a	49.6	51.0 a	48.7 a	45.2 a	48.5 a
Sig.	**	**	*	***	*	**
Plant spacing (m)						
2 x 2	29.6	26.3 b	19.8 b	17.0 b	15.6 b	21.7 b
2 x 3	50.5	50.1 a	55.7 a	47.5 a	46.1 a	50.0 a
3 x 3	51.0	46.6 a	51.7 a	48.4 a	44.9 a	48.5 a
Sig.	**	***	***	**	***	**
No. of suckers						
2	42.2	40.5 a	42.8 a	40.9 a	37.4 a	40.8 a
3	44.2	40.1 a	40.5 b	38.7 a	33.8 b	39.5 b
4	44.7	37.6 b	37.8 c	36.2 b	32.3 b	37.7 c
Sig.	*	*	*	*	*	*

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test. *,** and *** indicate significance at $P \leq$ 5%, 1% and 0.1%, respectively. PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

Table 1. Continued.

Clones	Total yield (ton/ha)					
	PC	R_1	R_2	R_3	R_4	Av.
DC	22.0 c	23.1 c	25.3 c	25.9 c	19.6 c	115.9 c
GN	25.5 b	28.2 b	31.6 b	24.5 b	22.9 b	132.7 b
WH	33.7 a	31.8	34.2	27.9	24.4	152.0 a
Sig.	**	*	*	*	*	**
Plant spacing (m)						
2 x 2	37.5 a	35.1 a	36.3 a	33.9 a	27.0 a	169.8 a
2 x 3	27.4 b	34.5 a	33.8 b	30.7 b	19.4 b	145.8 b
3 x 3	19.3 c	22.2	22.8 c	21.1 c	17.8 c	103.2 c
Sig.	**	***	***	***	***	**
No. of suckers						
2	29.3 a	31.8	30.6 a	27.1 a	25.5 a	144.3 a
3	37.3 a	30.5	27.9 b	24.7 b	22.2 b	142.6 a
4	27.7 b	29.5	24.7 c	21.9 c	19.3 c	123.1 b
Sig.	*	NS	**	***	***	**

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test. *,**,*** and NS indicate significance at $P \leq$ 5%, 1%, 0.1% and not significant, respectively. PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

Table 2. Interaction effects of banana clone and plant spacing on total and exportable yields of the plant crop and ratoons

Clones	Spacing (m)	Total yield (ton ha^{-1})					Total yield (cumulative)
		PC	R_1	R_2	R_3	R_4	
DC	2 x 2	30.2 d	33.9 b	34.5 b	31.4 b	26.8 c	156.8 b
	2 x 3	27.6 c	26.7 c	28.3 c	24.7 c	22.4 d	129.7 c
	3 x 3	13.3 f	19.0 e	22.6 e	16.0 e	14.5 f	85.4 f
GN	2 x 2	36.1 a	38.2 a	39.1 a	37.0 a	34.3 a	184.7 a
	2 x 3	21.8 d	34.0 b	35.3 b	30.5 b	29.1 b	150.7 c
	3 x 3	18.7 e	19.4 e	22.8 e	20.6 d	18.7 e	100.2 e
WH	2 x 2	46.3 a	37.4 a	38.3 a	32.2 b	30.5 b	184.7 a
	2 x 3	32.8 b	34.8 b	35.4 b	30.8 b	24.8 c	158.6 b
	3 x 3	22.0 d	23.4 d	25.2 d	23.7 c	20.6 d	114.9 e
Sig.		**	*	*	**	*	*

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test. * and ** indicate significance at $P \leq 5\%$ and 1%, respectively.
PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

Table 2. Continued.

Clones	Spacing (m)	Exportable yield (%)					
		PC	R_1	R_2	R_3	R_4	Av.
DC	2 x 2	23.8 e	24.7 f	27.5 e	25.2 e	22.7 e	24.8 d
	2 x 3	42.0 d	31.7 e	33.4 d	31.1 d	26.5 d	32.9 c
	3 x 3	56.3 c	34.3 d	36.3 c	34.2 d	30.6 c	38.3 b
GN	2 x 2	33.0 d	40.3 c	43.5 b	42.1 c	38.8 b	39.5 b
	2 x 3	59.6 b	55.6 b	56.7 ab	53.3 b	50.1 a	55.1 a
	3 x 3	51.9 a	62.2 a	62.9 a	60.5 a	54.7 a	58.4 a
WH	2 x 2	33.3 c	36.2 d	37.8 c	34.3 d	31.2 c	34.6 c
	2 x 3	57.3 b	54.0 b	56.7 ab	55.1 b	52.4 a	55.1 a
	3 x 3	60.5 a	58.5 a	59.3 a	57.6 a	54.5 a	58.1 a
Sig.		*	*	**	*	*	*

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test. * and ** indicate significance at $P \leq 5\%$ and 1%, respectively.
PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

The interaction effects of banana clones and number of suckers on total and exportable yields were significant (Table 3). Generally, total and exportable yields decreased as number of suckers increased in all clones. This was true for the plant crop and ratoons. Similar results were reported by Mohamed (2003).

Table 3. Interaction effects of banana clone and number of suckers on total and exportable yields of the plant crop and ratoons

Clones	No. of Suckers	Total yield (ton ha^{-1})					Total yield (cumulative)
		PC	R_1	R_2	R_3	R_4	
DC	2	26.3 e	28.1 c	24.7 c	23.6 c	15.6 b	118.3 d
	3	27.9 d	27.8 c	23.1 d	24.8 b	14.0 b	117.6 d
	4	20.9 g	23.7 d	20.9 e	22.8 c	14.1 b	102.4 f
GN	2	28.5 d	34.9 a	27.6 b	29.5 a	17.3 a	137.8 b
	3	25.6 e	30.7 b	25.8 c	25.1 b	14.8 b	122.0 d
	4	22.5 f	28.9 c	23.9 d	24.8 b	13.4 c	113.5 e
WH	2	36.7 a	35.9 a	29.9 a	25.3 b	17.7 a	145.5 a
	3	33.0 b	34.7 a	26.8 b	24.4 b	15.0 b	133.3 b
	4	31.5 c	34.0 a	26.4 b	24.0 b	13.3 c	129.2 c
Sig.		**	*	*	*	**	**

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
* and** indicate significance at P≤ 5% and 1%, respectively.
PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

Table 3. Continued.

Clones	No. of Suckers	Exportable yield (%)				
		PC	R_1	R_2	R_3	R_4
DC	2	36.1 d	20.9 e	31.2 d	35.6 f	32.6 e
	3	33.0 e	17.9 f	25.1 e	23.4 g	25.0 f
	4	36.4 f	14.6 g	18.2 f	20.7 h	22.4 g
GN	2	35.8 a	54.7 a	54.1 a	53.3 b	52.3 a
	3	46.5 b	46.6 d	50.4 c	50.2 c	46.9 c
	4	55.6 d	50.0 b	49.0 c	40.6 e	42.7 d
WH	2	44.7 a	54.7 a	54.5 a	56.5 a	51.2 a
	3	40.9 c	50.9 a	52.8 b	50.6 c	48.4 b
	4	55.6 c	48.0 c	50.0 c	47.5 d	43.9 d
Sig.		*	**	**	*	*

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
* and** indicate significance at P≤ 5% and 1%, respectively.
PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

The interaction effects of banana clones and plant spacing on time from planting to harvesting the fourth ratoon, cumulative and exportable yields were significant (Table 4). Regardless of spacing, the introduced clones WH and GN had significantly higher cumulative and exportable yields than the local clone DC. Similar results were reported by Elkashif *et al.* (2010). All clones took a longer time from planting to harvesting
the fourth ratoon at the closer spacing (2x2 m) than the wider spacing (3x3 m). This was due to the competition between plants imposed by the high plant population at the closer spacing and hence a slow rate of growth and a consequent delay in bunch shooting as compared to the wider spacing.

Table 4. Interaction effects of banana clone and plant spacing on time from planting to harvesting the fourth ratoon, cumulative and exportable yield

Clone	Spacing (m)	Time from planting to harvesting R_4 (mo)	Cumulative Yield (ton ha^{-1})	Exportable yield (%)
DC	2 x 2	36.3 a	130.9 c	23.6 g
	2 x 3	29.9 b	114.6 f	31.7 c
	3 x 3	27.9 c	93.4 i	40.4 d
GN	2 x 2	36.4 a	150.6 b	31.3 e
	2 x 3	30.1 b	120.4 e	46.2 b
	3 x 3	29.2 b	100.1 h	61.5 a
WH	2 x 2	36.1 a	156.7 a	26.7 f
	2 x 3	30.8 b	126.3 d	43.3 c
	3 x 3	26.3 c	104.6 g	64.2 a
Sig. level		**	*	**

Means in columns followed by the same letter(s) are not significantly different at P≤0.05 according to Duncan's Multiple Range Test.
*,** indicate significance at P≤ 5% and 1%, respectively.
R_4 indicate fourth ratoon.

Regardless of clone, cumulative yield was higher at the closer spacing than at the wider spacing. This was because the closer spacing resulted in a large number of plants per unit area which produced a large number of bunches and hence higher cumulative yield. However, exportable yield was higher at the wider spacing than the closer spacing for all clones. These results are in agreement with those reported by Elsiddig *et al.* (2009).

The interaction effects of plant spacing and number of suckers on the duration of time from planting to harvesting the fourth ratoon, cumulative and exportable yields were significant (Table 5). Regardless of number of suckers, the closer spacing took a longer duration of time than the wider spacing. However, under all plant spacings, the few number of suckers took a longer duration of time than the large number of suckers. The highest cumulative yield was produced by plants grown at the closer spacing with two suckers per mat and the lowest was produced by plants grown at the wider

spacing with four sucker per mat. However, the highest exportable yield was produced by plants grown at the wider spacing with
two suckers per mat and the lowest was produced by those grown at the closer spacing with four suckers per mat. This was due to the large number of plants per unit area which resulted in small bunches with small unexportable fingers. Similar results were reported by Mahmoud *et al.* (2010).

The main effects of banana clones, plant spacing and number of suckers on the duration of the crop cycle are shown in Table 6. Banana clones had no consistent effects on the crop cycles and did not follow a certain trend. Plant spacing, however, had significant effects on the crop cycles. The closer spacing resulted in longer crop cycles and the wider spacing resulted in shorter ones. This was because the large plant population encountered at the closer spacing resulted in a significant competition between plants which suppressed growth, delayed bunch shooting and hence resulted in longer crop cycles as compared to the wider spacing. Kesavan *et al.* (2002) reported similar results. Number of suckers had highly significant effects on crop cycles (Table 6). The few number of suckers resulted in longer crop cycles than the large number of suckers because the latters produced bunches in a successive way which shortened the crop cycles. This also resulted in an inverse relationship between number of suckers and the duration of time from planting to harvesting the fourth ratoon, which followed the same trend shown in Table 5.

Table 5. Interaction effects of plant spacing and number of suckers on the time from planting to harvesting the fourth ratoon, cumulative and exportable yield (ton ha^{-1}).

Spacin (m)	No. of suckers	Time from planting to harvesting R_4 (mo)	Cumulative yield (ton ha^{-1})	Exportable yield (%)
2 x 2	2	38.2 a	150.7 a	29.3 f
	3	35.0 b	144.8 b	27.7 f
	4	34.4 b	132.6 d	22.5 g
2 x 3	2	31.4 c	140.4 c	52.4 c
	3	29. 5 d	134.9 d	46.3 d
	4	29.4 d	130.0 e	41.7 e
3 x 3	2	28.8 e	106.2 f	62.4 a
	3	28.5 e	99.1 g	56.3 b
	4	25.9 f	92.8 h	51.7 c
Sig.		*	*	**

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.
* and ** indicate significance at $P \leq 5\%$ and 1%, respectively.
R_4 indicate fourth ratoon.

Fruit green life and TSS

Fruit green life is a very important parameter in the banana industry. Clones with long green lives can be safely shipped from countries of production to distant markets without any signs of deterioration. Hence, fruit green life and TSS content are used as criteria for screening and selection of promising banana clones for commercial production (Dadzie and Orchard, 1997).

The main effects of banana clones and plant spacing on fruit green life and total soluble solids (TSS) content of the plant and ratoon crops were significant (Table 7). The green life of the introduced clones GN and WH was significantly longer than that of the local clone DC for both the plant and ratoon crops. These results confirm previous findings (Mahmoud and Elkashif, 2003; Elkashif *et al.*, 2005; Elkashif *et al.*, 2010).

Table 6. Main effect of clone, plant spacing and number of suckers on the duration of the crop cycles (months).

Clone	From planting to harvesting of the plant crop	Plant crop to 1st ratoon	1st to 2nd ratoon	2nd to 3rd ratoon	3rd to 4th ratoon	From planting to 4th ratoon
DC	7.99 c	3.19 a	5.66	4.43 a	4.18 b	31.39
GN	9.60 b	2.56 b	5.57	4.33 ab	5.24 a	31.88
WH	10.10 a	2.62 b	5.37	3.45 c	5.44 a	31.03
Sig.	*	*	NS	*	*	NS
Plant spacing (m)						
2x2	9.20	2.88	6.13 a	7.03 a	6.77 a	36.26 a
2x3	8.90	2.51	5.23 b	5.33 b	4.21 b	30.17 b
3x3	9.80	2.66	5.20 b	4.68 c	4.16b	27.74 c
Sig.	NS	NS	*	*	**	***
Number of suckers						
2	9.40	3.80 a	5.74 a	6.46 a	7.64 a	32.97 a
3	9.60	2.75 b	4.84 b	4.93 b	5.19 b	29.27 b
4	9.00	1.90 c	4.02 b	3.64 c	4.32 c	27.73 c
Sig.	NS	***	***	***	***	***

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

*,**,*** and NS indicate significance at 5%, 1%, 0.1% and not significant, respectively.

Banana clones significantly differed in the TSS content of the plant crop and ratoons (Table 7). The introduced clones had significantly lower TSS content than the local clone DC. These results are in agreement with those reported by Mahmoud and Elkashif (2003). Plant spacing had significant effects on fruit green life (Table 7). The wider spacing resulted in significantly longer green life than the closer spacing in both the plant and

ratoon crops. This was because plants grown at a wider spacing produced large, well developed bunches with large fingers which were more likely to have a longer green life than those produced at a closer spacing.

Plant spacing also had significant effects on fruit TSS content of the plant and ratoon crops (Table 7). Likewise, the wider spacing resulted in significantly higher TSS content than the closer spacing. This was because the large, well developed fingers produced under the wider spacing were more expected to ripen normally with excellent fruit characteristics including high TSS content than those produced under closer spacing.

Table 7. Main effect of banana clone and plant spacing on green life and TSS of the plant crop and rations.

Clone	Green life (days)					
	PC	R_1	R_2	R_3	R_4	Av.
DC	14.04 c	12.03 b	12.96 b	14.63 c	14.26 b	13.58 b
GN	16.37 b	14.74 a	14.15 a	16.11 b	16.67 a	15.61 a
WH	17.29 a	14.07 a	14.26 a	17.19 a	16.74 a	15.91 a
Sig.	*	*	*	*	**	
Plant spacing (m)						
2 x 2	14.11 b	11.11 c	10.37 b	12.98 b	13.37 c	12.39 b
2 x 3	16.96 a	14.15 b	15.70 a	17.30 a	16.82 b	16.19 a
3 x 3	16.32 a	15.62 a	15.30 a	17.74 a	17.48 a	16.49 a
Sig.	**	***	*	***	***	**
CV %	9.74	18.28	17.69	19.78	17.73	

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

*,** and *** indicate significance at 5%, 1% and 0.1%, respectively.

PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

Table 7. Continued.

Clone	TSS (%)					
	PC	R_1	R_2	R_3	R_4	Av.
DC	20.13 a	19.83 a	19.15 a	20.17 a	19.33 a	19.76 a
GN	19.96 b	18.04 b	18.04 b	17.82 b	17.37 b	18.25 b
WH	19.00 b	17.59 b	17.59 c	17.96 b	17.33 b	17.89 b
Sig.	*	*	*	*	*	*
Plant spacing (m)						
2 x 2	17.11 c	18.87 c	16.87 c	18.11 b	17.67 c	17.73 b
2 x 3	18.52 b	19.89 b	18.82 b	18.84 b	18.04 b	18.82 b
3 x 3	19.63 a	20.37 a	20.30 a	19.09 a	19.60 a	19.80 a
Sig.	*	**	*	*	*	*
CV %	9.44	13.19	11.78	12.12	14.48	

Means in columns followed by the same letter(s) are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test.
* and ** indicate significance at 5% and 1%, respectively.
PC, R_1, R_2, R_3 R_4 and Av. Indicate plant crop, first, second, third, fourth ratoon and average, respectively.

In conclusion, the introduced clones GN and WH outyielded the local clone DC. In order to produce high total and exportable yields of fruit, it is recommended to grow banana plants at a spacing of 2x3 m and keeping three suckers per mat.

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تأثير مسافات الزراعة وعدد الخلف على الإنتاجية وجودة الثمار للمحصول الأم والأربعة خلف التالية لبعض سلالات الموز في أواسط السودان

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الخلاصة

أجريت هذه التجارب بمزرعة بحوث المعهد القومي لتنمية الصادرات البستانية جامعة الجزيرة , السودان في الفترة من يناير 2001 إلي ابريل 2004م لدراسة تأثير مسافات الزراعة وعدد الخلف على الإنتاجية ودورة المحصول وجودة الثمار للمحصول الأم والأربعة خلف التالية لبعض السلالات المستجلبة من الموز وهي هجين و ليم 172 والجراند نين 1824 مقارنة بالصنف المحلي 3 م. عدد الخلف 2،3 أو 4 خلفه حول النبات الأم. صممت 3x م و3x 2 م و2xالكافندش القزم. أبعاد الزراعة كانت كالآتي: 2 أعلى WH و GNالتجربة علي نسق استخدام التصميم المنشق بثلاثة مكررات. أعطت السلالات المستجلبة من خارج السودان ، في النبات الأم والأربعة DCأوزان للسبائط وأعلى الإنتاجية الكلية وكذلك الإنتاجية القابلة للتصدير بالمقارنة مع السلالة المحلية خلف الأولى. كذلك أعطت السلالات المستجلبة أطول فترة للعمر الأخضر للثمار ولكنها أعطت أقل محتوى من المواد الصلبة متر أعطت أعلى أوزان للسبائط وأعلى إنتاجية للموز القابل 3 x. زراعة الموز بأبعاد 3 DCالذائبة مقارنة بالسلالة المحلية متر، وذلك في النبات الم والأربعة خلف التالية. كذلك 2 x 2للتصدير ولكن الإنتاج الكلي كان أقل بالمقارنة مع الزراعة في أبعاد متر أطول فترة للعمر الأخضر للثمار وأعلى محتوى من المواد الصلبة الذائبة مقارنة بالزراعة 3 x 3أعطت الزراعة في أبعاد متر). عند ترك 3 x متر) دورة محصولية أطول بالمقارنة مع الزراعة المتباعدة (3 2 x 2المتقاربة. أعطت الزراعة المتقاربة (خلفتين مع النبات الأم، أدى ذلك إلى أعلى أوزان للسبائط وأعلى إنتاجية كلية وأعلى إنتاجية من الموز القابل للتصدير وأطول دورة محصولية في النبات الأم والخلف الأربعة التالية، وذلك بالمقارنة مع ترك أربعة خلف مع النبات الأم.