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Adjusting the Best Time of Planting Suckers and Plant Density for Williams Banana Grown under Aswan Region Conditions

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ABSTRACT

Planting date and density have great effect on growth, cycling time and yield of banana. The objectives of this study were to select the optimum planting date and plant density, that determining growth, flowering, yield and fruit quality under Aswan conditions. During 2008 to 2009 and 2009 to 2010 seasons, Williams banana Suckers were planted at the middle of Feb., Mar. and April at plant population 1000, 444 and 250 mother plants and 1000, 888 and 750 first ratoon. March planted Banana was a gradual promotion and significant on all growth characters, as well as the heavier bunches (8.4 and 15.5 kg) with maximum hand weight (1.92 and 2.15 kg). While April planted Banana gave the lowest ones in this respect in both seasons. The earliest shooting, minimum days for harvesting and cropping cycle (303.97 and 522.84 days) were observed with February planted during mother plants and first ratoon. For the optimum crop timing (316.34 and 536.7 days), first ratoon selection and the best fruit quality were noticed with March planting only. Increasing density reduced individual plant growth, chemical characteristics and productivity per plant, however gave the higher yield per area as well as delaying cropping cycle about (8-10 days). At low densities the highest values of chemical characteristics were observed, however planting date failed to show significant effect of all chemical characteristics. In regard to best fruit quality, yield and selection ratoon were obtained with planting Williams's suckers at March with plant density 444 mother plants with two suckers per hole.

Key words: Banana plants, plant population, planting suckers, cropping cycle selection ratoons

INTRODUCTION

Banana is one of the most important and favorable fruit crops in Egypt. The area planted for Williams banana cultivated in 2010 was 20156 fad., as fad. is equal to 4200 m^2 (Ministry of Agriculture, 2010). The growers in Aswan planted banana during Feb. to April without any adequate spacing on proper plant population per unit. Therefore a study was conducted to evaluate the effect of different planting time and plant density on the parameters of growth, development and production under Aswan conditions.

Growth and fruiting on banana cultivars were directly influenced by plant densities (Odeke *et al*., 1999). Thus, under wider spacing, all vegetative growth parameters except plant height were gradually increased, in contrast, with closer spacing which recorded the maximum plant height and yield per area (Athani *et al*., 2009). With no affected in fruit quality, on the other hand, bunches weight was lower and increased in time to flowering and harvesting (Maharana and Das, 1996). Several studies have indicated that plant densities were considered an important and limiting factor governed growth, nutritional status of the plants and fruiting of various banana cultivars (Robinson and Nel, 1988; Abd-Allah, 1999; Kluge *et al*., 1999; Apshara and Sathiamoorthy, 1999).

Therefore, the optimum planting density of banana that affected by many factors such as, cultivars, sucker selection, soil fertility and management level (Belalcazar and Espinosa, 2008; Athani and Hulamani, 2000; Nalina *et al*., 2000; Sayed-Shren, 2004; Ali, 2005).

Selecting the best time of planting different banana cultivars had an essential factor for dictated the time of crop harvesting as well as stimulating growth and development of fruits and first ratoon furthermore to avoid certain climatic conditions. These studies were carried out by (Simmonds, 1970; Hotsonyame, 1991; Ghose and Hossain, 1992; Abd-Allah *et al*., 2011).

The main goal of this study was selecting the best time of planting suckers and plant density that were responsible for promoting yield quantitively and qualitatively of Williams banana.

MATERIALS AND METHODS

This study was carried out during 2008 to 2009 and 2009 to 2010 seasons under drip irrigation system on mother plants (produced by tissue culture) and first ratoon of Williams banana. The orchard is situated at Wady El-Nokra region, Aswan Governorate where the texture of the soil was sandy. Soil analysis was done according to the procedures that outlined by Black *et al*. (1965) (Table 1).

Experimental treatments and design: The study design in split plot and the treatments were arrangement in complete randomized block design. The three dates of planting suckers namely mid. of Feb, mid. of Mar. and mid. of Apr were used as the main plot (factor A). The three plant density namely (2×2 m), i-e. 1000 mother plants with one sucker per hole, (3×3 m), i-e. 444 mother plants with two suckers per hole and (4×4 m), i-e. 250 mother plants with three suckers per hole in first and second ratoons per fad.) (factor B). The study contained nine treatments. Each treatment

Table 1: Physicochemical analysis of the soil used in study

Characters	Values
Sand (%)	87.9
Silt (%)	5.1
Clay (%)	7.0
Texture	Sandy
pH (1:2.5 extract)	7.9
EC (Electrical conductivity) (1:2.5 extract) (mmhos per 1 cm per 25°C)	1.6
O.M. (%) (organic matter)	0.7
$CaCO_3$ (%)	2.2
Total N (%)	0.06
Available P (Olsen, ppm)	2.1
Available K (ammonium acetate, ppm)	33.0
Soluble catious (meq L^{-1})	
Ca^{++}	2.55
Mg^{++}	2.00
Na^{+}	1.57
K^{+}	0.07
Soluble anious (meq L^{-1})	
HCO_3^{-}	2.4
SO_4^{-}	1.97
Cl^{-}	1.82

was replicated three times, three stools per each. The selected Williams banana plants received the regular and common horticultural practices that are already applied in the orchard. On the first week of July 2008 the first ratoon were chosen and remove other. Following parameters were studied during the experiment.

Vegetative growth: After the emergence of the inflorescence growth characters namely height (cm) and girth (cm) of pseudostem, number of green leaves per plant at bunch shooting leaf area (m^2) using the third full size leaf (from the top) was calculated in square meters according to Murry (1960) and then, total surface per plant (m^2) were measured:

$$\text{Leaf area } (m^2) = (\text{Length} \times \text{Width}) \times 0.8$$

Flowering parameters: Period to 50% bunch shooting, period to harvest and cropping cycle were calculated as a period in days.

Bunch characteristics: At harvest, bunch weight (kg) per plant and hand weight (kg) was recorded.

Finger physical and chemical characteristics: After artificial ripening, weight of finger (g), pulp per peel, starch (%), total soluble solids (%), total reducing and non-reducing sugars (%) and total acidity (%) (as g malic acid per 100 g pulp) were determined according to AOAC (1995). All the obtained data were tabulated and statistically analyzed using new LSD at 5% for comparing between different treatment means (Mead *et al.*, 1993).

RESULTS AND DISCUSSION

Vegetative growth

Height and girth pseudostem: It is clear from the data in Table 2 that varying times of planting mother plants of Williams banana had a significant effect on height and girth of pseudostem. Promotion on these growth characters celery showed with middle March planting, which recorded the maximum values (212.5 and 222.83) and (78.7 and 79.4) in height and girth pseudostem during the first and second seasons, respectively. Whereas the lowest values showed with middle April planted banana. (198.4 and 208.33) and (75.6 and 76.3) in this respect in both seasons. These results due to the suitable condition for growing and growth during middle March than other timing for the mother plants under Aswan region. The data also showed that, decreasing plant densities from 1000 to 250 mother plants per fad. Significantly stimulated height and girth pseudostem (cm). The highly pseudostem was noticed with the highest plant population (1000 mother plant with 1000 first rations per fad.) and vice versa. At the same time pseudostem girth decreasing gradually with increasing plant densities from 1000 to 250 mother plants and first rations. The best effects of planting date and distribution on height and girth of pseudostem of Williams banana were noticed with mother plants at 3×3 m and leaving three suckers per hole (444 mother plants and 888 first rations per fad.) in the mid of March gave the best results on growth characters, during both seasons.

The results of dates of planting are in agreement with those obtained by Hotsonyame (1991), Ghose and Hossain (1992) and Abd-Allah (1999). They observed that, early planting date during March of Williams banana recorded The highest values on height and girth of pseudostem. In

Table 2: Effect of different times of planting and plant densities on some growth vegetative characters and period to 50% bunch shooting (day) of Williams banana plants during 2008-2009 and 2008-2009 seasons

	Plant densities per fad. (B)															
	Pseudostem height (cm)								Pseudostem girth (cm)							
	2008-2009				2009-2010				2008-2009				2009-2010			
Time of planting (A)	1000	444	250	Mean (A)	1000	888	750	Mean (A)	1000	444	250	Mean (A)	1000	888	750	Mean (A)
15 February	206.30	201.00	199.40	202.33	219.50	214.30	206.60	213.47	75.9	77.9	78.0	77.3	76.6	78.5	78.6	77.9
15 March	215.00	212.50	210.00	212.50	230.20	222.00	216.30	222.83	77.3	79.4	79.5	78.7	78.0	80.0	80.2	79.4
15 April	201.60	198.60	195.00	198.40	215.10	207.90	202.00	208.33	74.1	76.3	76.5	75.6	74.8	77.0	77.1	76.3
Mean (B)	207.60	204.03	201.50		221.60	214.73	208.30		75.8	77.9	78.0		76.5	78.5	78.6	
$L.S.D_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	2.0	2.1		3.6	2.0	2.1		3.6	0.5	0.6		1.0	0.5	0.5		0.9
	No. of green leaves per plant								Leaf area (m^2)							
15 February	11.0	12.0	12.0	11.7	12.0	13.0	13.0	12.7	0.79	0.83	0.84	0.82	0.81	0.84	0.93	0.86
15 March	12.0	13.0	13.0	12.7	13.0	13.0	13.0	13.0	0.85	0.90	0.91	0.89	0.87	0.92	0.94	0.91
15 April	10.0	11.0	11.0	10.7	11.0	13.0	13.0	12.3	0.75	0.80	0.81	0.79	0.76	0.81	0.81	0.79
Mean (B)	11.0	12.0	12.0		12.0	13.0	13.0		0.80	0.84	0.85		0.81	0.86	0.89	
$L.S.D_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	1.0	1.0		1.7	1.0	0.7		1.2	0.03	0.03			0.03	0.03		
	Total surface area per plant (m^2)								Period to 50% bunch shooting (day)							
15 February	8.7	10.0	10.1	9.6	9.6	10.8	10.9	10.4	185.60	181.30	179.25	182.05	412.16	406.54	405.25	408.00
15 March	10.2	11.7	11.8	11.2	11.2	11.8	12.0	11.7	194.29	188.20	185.00	189.16	422.12	416.22	411.11	416.50
15 April	7.5	8.8	8.9	8.4	8.3	10.4	10.4	9.7	203.18	197.27	191.00	197.15	425.12	415.34	412.11	417.52
Mean (B)	8.8	10.2	10.3		9.7	11.0	11.1		194.36	188.92	185.1		419.8	412.7	409.5	
$L.S.D_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	0.6	0.6		1.0	0.6	0.6		1.0	1.37	1.42		1.51	1.67	1.73		1.80

A, B and AB represent LSD value time of planting (A), plant densities (B) and time of planting×plant densities (A×B), respectively

addition, Abd-Allah *et al.* (2011) who reported that under Nobaria region, mid March. planted banana gives the best growth characters than advanced and later dates. These results concerning plant densities are in harmony with those obtained by Robinson *et al.* (1994), Abd-Allah (1999), Ali (2005) and Athani *et al.* (2009). They found that wider spacing have a positively effect on all growth parameters except plant height.

Number of green leaves per plant: Data in Table 2 showed the number of green leaves per plant in response to the planting date and densities of mother plant and first ratoon cycle, Williams banana under Wady El-Nokra region, Aswan Governorate. The results indicated that, there was a significant difference between the three planting dates (in the first seasons only) Whereas the best results observed with middle March planted banana were (12.7 and 13.0) during mother plants and first ratoon, respectively. With regard to the effect of density on number of green leaves per plant, there were no significant differences observed between three plant densities. The wider spacing i.e. low density planting (250 mother plant and 750 first rations per fad.) and medium density planting (444 mother plants at 3×3 m with two suckers per hole in the first and second ratoons per fad.) recorded the highest values in this respect in both seasons. Meanwhile the closer spacing i.e. high density planting (1000 mother plant and 1000 first ratoons per fad.) recorded the lowest values in number of green leaves per plant (11.0 and 12.0) in both seasons. These results might be due to decrease plant population per fad. lead to less competition in soil moisture nutrient and light intensity at shooting and harvesting stages as compared to closer spacing with higher plant density Chaudhuri and Baruah (2010); Nalina *et al.* (2000). The best results in number of functional leaves per plant were found in mid March accompanied with medium and wider spacing, i.e. (444 mother plants at 3×3 m with two suckers per hole in the first and second ratoons per fad.) and (250 mother plants at 4×4 m with three suckers per hole in the first and second ratoons per fad.) in the first and second one.

The present results of dates of planting are in agreement with those obtained by Hotsonyame (1991) and Ghose and Hossain (1992) found that number of green leaves at bunch shooting was affected by planting dates. On the other hand, Baghdadi *et al.* (1959), Robinson and Nel (1986) and Abd-Allah (1999) noted that the number of green leaves per plant at time of flowering was not constant, being more in the plants which flowered in late summer and its fall and less in those which flowered in spring and early summer.

These results concerning plant densities are in harmony with those obtained by and Ali (2005); Chaudhuri and Baruah (2010) reported that closer spacing decreased number of green leaves as compared to wider spacing.

Leaf area: Concerning the third leaf area (m^2) from Table 2 data showed that there were a significant differences among the three planting date. Mid March-planted banana was significantly increasing leaf area (0.89 and 0.91 m^2) in the first and second one. Whereas planting date in mid February and mid April were decrease leaf area in ascending order during both seasons. Wider spacing have a positively effect on leaf area than closer spacing. Since there were no significant effects between the two plant densities at 3×3 m with two suckers per hole and 4×4 m with three suckers per hole in both seasons. At the same time the lowest values and significant decreasing leaf area (0.80 and 0.81 m^2) were noticed with closer spacing (1000 mother plant and 1000 first rations). These could be attributed to high density planting lead to excessive interception of sunlight gradually that responsible for decreasing the leaf area (m^2) (Singh and Kashyap, 1992). The best results between planting date and densities were observed with wider spacing 4×4 m (250 mother

plants per fad with three suckers per hole) at mid March which were (0.91 and 0.94 m^2) in both seasons. Similar results on Williams banana of dates and planting are in agreement with those obtained by Hotsonyame (1991) and Ghose and Hossain (1992). At the same direction, Abd-Allah *et al.* (2011) who noted that Mother plants which planted at mid Mar. recorded the highest values in leaf area (m^2) than mid Feb. and mid Apr. under Nobaria region. These results regarding plant densities are in agree with those obtained by Robinson *et al.* (1994); Abd-Allah (1999); Ali (2005); Athani *et al.* (2009). They observed that wider spacing have a positively effect on leaf area (m^2) that may be due to a larger number of leaves accompanied with bigger size of leaves.

Total surface area per plant: Data in Table 2 show clearly that total surface area per plant (m^2) significantly varied with planting dates. Highest total area per plant (11.2 and 11.7 m^2) was observed with mid March planted banana. The total surface area per plant gradually decreased in mid Feb. and mid. April. Mid February planted banana recorded the intermediate values in total surface area per plant (9.6 and 10.4 m^2) in both seasons, respectively. On the other hand, the total surface area per plant of Williams banana significantly affected with varying plant density. Under high density planting at 2×2 m apart (1000 mother plant and 1000 first ratoons) gives the lowest total surface area per plant (8.8 and 9.7 m^2) in both seasons. The positive effect of total surface area per plant was noticed with the plant densities 4×4 m apart (250 mother plants per fad with three suckers per hole), followed by without any significant when mother plant densities were 3×3 m with two suckers per hole. Regarding the favorite interaction between planting date and distribution were noticed with wider spacing 4×4 m (250 mother plants per fad and three suckers per hole) at mid March (11.8 and 12.0 m^2).

The noticeable performances of the total surface area per plant (m^2) on Williams banana could be attributed to under wider spacing the more leaf surface was exposed to sunlight and indirectly great amount of assimilates accumulated in the plant leading to increased total surface area per plant. Chaudhuri and Baruah (2010). These finding with planting dates treatments are in agreement with those reported by Hotsonyame (1991); Ghose and Hossain (1992); Abd-Allah *et al.* (2011) who observed the best total surface area per plant (m^2) was noticed at mid March planted banana than other dates. The promising effect of plant densities on total surface area per plant (m^2) were emphasized by Abd-Allah (1999), Ali (2005), Athani *et al.* (2009) and Chaudhuri and Baruah (2010). They observed that wider spacing have a positively effect on total surface area per plant (m^2).

Flowering parameters: Data in Table 2 and 3 showed that the period of days from 50% of bunch shooting (50% flower emergence) and from shooting to bunch harvesting, also cropping cycle were significantly affected by planting dates. These duration were prominently increased with advancing dates of planting. Mid February planted banana recorded significantly shortened the period to bunch shooting, harvesting and cropping cycle (days) compared to mid. April planted banana. As well as Cropping cycle (days) of mid. February were (303.97 and 522.84 days) during mother plants and first ratoon, while were (331.64 and 544.73 days) for mid April planting time, respectively, whereas, the medium cropping cycle obtained with mid. March planted banana (316.34 and 536.7 days). In regard to cropping cycle both mid. February and mid April planting were harvesting during the undesirable conditions and this effect was largely carried over into the first ratoon and follow ratoons. These results were supported from the study of Robinson and Nel (1986); Hotsonyame (1991). Adjusting planting date not only avoiding high temperature at the emergence

Table 3: Effect of different times of planting and plant densities on period to harvest (day), cropping cycle (day) and physical bunch characteristics of Williams banana plants during 2008-2009 and 2009-2010 seasons

	Plant densities per fad. (B)															
	Period to harvest (day)								Cropping cycle (day)							
	2008-2009				2009-2010				2008-2009				2009-2010			
Time of planting (A)	1000	444	250	Mean (A)	1000	888	750	Mean (A)	1000	444	250	Mean (A)	1000	888	750	Mean (A)
15 February	125.65	121.60	118.50	121.92	120.33	115.57	112.66	116.19	311.25	302.90	297.75	303.97	528.49	522.11	517.91	522.84
15 March	131.18	128.14	125.20	128.17	125.44	121.18	115.94	120.85	325.47	316.34	310.20	316.34	545.65	537.40	527.05	536.70
15 April	138.80	136.00	128.66	134.49	131.71	123.16	119.87	125.00	341.98	333.27	319.66	331.64	553.83	538.50	531.98	544.73
Mean (B)	131.88	128.25	124.12		125.83	120.00	116.20		326.23	317.50	309.20		542.66	534.96	526.65	
$L.S.D_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	1.73	1.16		1.26	1.28	1.14		1.32	3.26	3.85		3.92	3.32	3.68		3.74
	Bunch weight (kg)								Hand weight (kg)							
15 February	6.9	7.6	7.7	7.4	13.5	14.2	14.3	14.0	1.8	1.88	1.89	1.86	1.95	2.04	2.05	2.01
15 March	8.0	8.6	8.7	8.4	15.0	15.7	15.8	15.5	1.87	1.94	1.95	1.92	2.10	2.17	2.18	2.15
15 April	6.0	6.6	6.7	6.4	12.0	12.6	12.7	12.4	1.71	1.79	1.80	1.77	1.85	1.91	1.92	1.89
Mean (B)	7.0	7.6	7.7		13.5	14.2	14.3		1.79	1.87	1.88		1.97	2.04	2.05	
$L.S.D_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	0.5	0.5		0.7	0.4	0.5		0.7	0.05	0.05		0.07	0.05	0.05		0.07
	Finger weight (g)								Pulp/peel							
15 February	96.2	99.0	99.4	98.2	97.3	102.5	102.8	100.9	3.2	3.5	3.6	3.4	3.3	3.5	3.6	3.5
15 March	100.0	103.0	103.0	102.0	102.0	106.0	106.5	104.8	3.4	3.6	3.7	3.6	3.5	3.6	3.7	3.6
15 April	92.2	95.0	95.3	94.2	95.0	99.0	99.6	97.9	3.0	3.2	3.3	3.2	3.1	3.2	3.3	3.2
Mean (B)	96.1	99.0	99.2		98.1	102.5	1030		3.2	3.4	3.5		3.3	3.4	3.5	
$L.S.D_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	2.1	2.0		3.0	2.1	2.0		3.0	0.2	0.2		0.3	0.2	0.2		0.3

A, B and AB represent LSD value time of planting (A), plant densities (B) and time of planting×plant densities (A×B), respectively

of bunches but also, stimulating growth and development of fruits. That lead to select the best first ratoon in June (favorite time in Egypt) (Abd-Allah *et al.*, 2011). The period from bunch shooting, bunch shooting to bunch harvest and cropping cycle were differed significantly among the different plant densities (Table 2 and 3). Earlier bunch shooting and shorter periods to harvest as well as Cropping cycle (days) during mother plants and first ratoon were observed under wider spacing. The plants spaced at 4×4 m (250 mother plants per fad and three suckers per hole) emerged their bunches about 9-10 days significantly earlier than plants spaced at 2×2 m (1000 mother plant and 1000 first ratoons), respectively. At the same trend, bunches of plants under closer spacing 2×2 m, with one suckers per hole) were harvested later than the other plants under wider and medium spacing. Plants spaced at 4×4 m (250 mother plants with three suckers per hole) had the earliest Cropping cycle (days) (309.2 and 526.65 days) than two plants spaced at 3×3 m (317.5 and 534.96 days) and 2×2 m (326.23 and 542.66 days) in mother plants and first ratoon, respectively. This might be due to more leaf surfaces exposed to light in low density planting, which increased the metabolism of plant causing early physiological maturity and flowering. The obtained results are in accordance with those reported by Robinson and Nel (1986), Athani *et al.* (2009), Chaudhuri and Baruah (2010) and Abd-Allah *et al.* (2011), who observed that plants with close space took the longest time for the emergence of their inflorescence and the period from flowering to harvest compared to plants cultivated at wider spacing.

Bunch characteristics

Weights of bunch and hand: It is evident from the data in Table 3 that weights of bunch and hand (kg) were significantly affected by planting dates. The plants were planted in the middle of March significantly produced maximized weights of bunch (8.4 and 15.5 kg) and the largest hand weight (1.92 and 2.15 kg) in the mother plant and first ratoon cycle, respectively. Meanwhile, the minimum values for the bunch and hand weight were obtained from the middle April planted. Such finding may be due to under Aswan conditions, middle March was the best time for planting rather than the other dates, which the suitable humidity and optimum temperature 25-30°C that was essential for improving growth with high quality of fruit (Simmonds, 1970).

The same Table 3 shows that the reduction in yield is in inverse proportion to density increase. Bunch and hand weigh (kg) were significantly improved with wider spacing than closer spacing. The highest values of Bunch (7.7 and 14.3) and hand weigh (1.88 and 2.05) were recorded with plants spaced at 4×4 m (250 mothers and 750 first ratoons hole). Increasing number of mothers from 250 to 444 and first ratoons from 750 to 888 per fad. had a slight and insignificant promotion on the yield and bunch weight.

While the lowest weights of bunch (kg) (7, 0 and 13, 5) and hand (kg) (1,79 and 1,97) were observed with plants spaced at 2×2 m (1000 mothers and 1000 first ratoons). Significance of high density planting in augmenting total yield per fad. in banana has already been elucidated by Challopadhay *et al.* (1985). They noted that production increases in plantain from 270 to 345% with densities of 3000 and 5000 plants per ha compared to the conventional 1000 plants per ha. It was also Lichtemberg *et al.* (1998) observed that the number of hands and fingers per bunch were decreased with increasing plant population. Perhaps this may be the reason that.

Planting mother plants of Williams banana on middle March with plants spaced 4×4 m (250 mothers and 750 first ratoons) gave the best results with regard to bunch weight reached 8.7 kg for mother plants and 15.8 kg for the first ratoons during the first and second seasons, respectively. On the other hand, the best yield per area showed with plants spaced 2×2 m (1000 mothers and 1000 first ratoons) (7000 and 13500 kg) followed by plants spaced 3×3 m (444 mothers and 888 first ratoons (3374.4 and 12610 kg) while the lowest plant population with

plants spaced 4×4 m (250 mothers and 750 first ratoons) gave the lowest yield per area (1925 and 10725 kg) during mother plants and first rations, respectively.

Such findings of plant densities are in agreement with those obtained by Robinson *et al.* (1994), Abd-Allah (1999), Ali (2005), Sayed-Shren (2004), Athani *et al.* (2009) and Chaudhuri and Baruah (2010) who indicated that most of growth, yield and quality parameters were significantly influenced by plant densities. The increase in the number of plants per hectare has a direct influence on growth and production.

Results obtained of mother plants dates are agree with those of previous study of Watson and Moncur (1985), Ghose and Hossain (1992) and Abd-Allah *et al.* (2011), they observed that the best planting date which gave the best vegetative growth, heavier bunches with good quality of fruits and suitable period for flowering and harvesting.

Finger physical and chemical characteristics

Finger weight and pulp per peel: Data in Table 3 obviously reveal that finger weight and pulp per peel were significantly enhanced with planting the mothers at mid. of March rather than the other dates. A significantly higher finger weight (g) (102 and 104.8) and (3.6 and 3.6) were found in the middle of March. Delaying and advancing the dates of planting were decreased finger weight and pulp per peel gradually. This reduction of finger weight with delaying planting date may be due to a high temperature and low humidity during middle of April on the other hand early flowering was observed with advancing planting dates (middle February) under Aswan conditions that interception the growth. Similar results was also reported by Bauri *et al.* (2002) most varieties of Bananas in the first stage grow best under high humidity of 50% or higher with the optimal growth at 27°C and stop entirely when temperature reaches 38°C.

Data in Table 3 showed that the weight of finger (g) (96.1 and 98.1) and pulp per peel (3.2 and 3.3) per plants were lower and significant under closer spacing (2×2 m apart with one suckers per hole). Meanwhile wider spacing was a positively effect on finger weight (g) therefore the plant densities (4×4 m apart with three suckers per hole) produced heavier finger weight (99.2 and 103.0) and pulp per peel (3.5 and 3.5) Followed by plant densities(3×3 m. apart with two suckers per hole) without any differences between, which registered finger weight (99.0 and 102.5) and pulp per peel and (3.4 and 3.4). Similar trend was observed during both seasons.

The best combination between planting dates and plant densities on finger weight (g) and pulp per peel in Table 3 were observed with Planting mother plants of Williams banana on the middle of March under lower density planting (4×4 m. apart with three suckers per hole) gave the best results (103.0 and 106.5) and (3.7 and 3.7) with regard to finger weight (g) and pulp per peel for the mother plants and first ratoon, respectively.

The present study of planting dates gets ample support from the work of Hotsonyame (1991) and Ghose and Hossain (1992). They observed that optimum planting dates resulting as the suitable condition for leaf activity, that increased amount of nutrients accumulation and markedly growing and growth than other timing. Such results of plant densities are in agreement with those obtained by Robinson *et al.* (1994), Abd-Allah (1999), Ali (2005), Sayed-Shren (2004), Athani *et al.* (2009) and Chaudhuri and Baruah (2010) indicated that most of growth, yield and quality parameters were significantly influenced by plant densities. The increase in the number of plants per hectare has a direct influence on growth and production.

Chemical characteristics of the fruits: From the data in Table 4 percentage of starch, percentage of total soluble solids, total, percentage of reducing and non-reducing sugars and

Table 4: Effect of different time of planting and plant densities on some chemical characteristics of fruits of Williams banana plants

	Plant densities per fad. (B)															
	Starch (%)								Total soluble solids (%)							
	2008-2009				2009-2010				2008-2009				2009-2010			
Time of planting (A)	1000	444	250	Mean (A)	1000	888	750	Mean (A)	1000	444	250	Mean (A)	1000	888	750	Mean (A)
15 February	1.31	1.34	1.36	1.34	1.36	1.42	1.44	1.41	18.6	19.3	19.5	19.1	18.8	19.9	20.0	19.6
15 March	1.31	1.39	1.40	1.37	1.36	1.42	1.44	1.41	18.5	19.3	19.5	19.1	18.8	19.9	20.0	19.6
15 April	1.32	1.38	1.39	1.36	1.35	1.42	1.44	1.40	18.5	19.3	19.5	19.1	18.9	19.9	20.0	19.6
Mean (A)	1.31	1.37	1.38		1.36	1.42	1.44		18.5	19.3	19.5		18.8	19.9	20.0	
L.S.D$_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	NS	0.03		NS	NS	0.03		NS	NS	0.05		NS	NS	0.05		NS
	Total sugars (%)								Reducing sugars (%)							
15 February	13.0	13.6	13.6	13.4	13.0	14.2	14.3	13.8	4.1	4.5	4.6	4.4	4.3	4.6	4.7	4.5
15 March	13.0	13.7	13.7	13.5	12.9	14.2	14.3	13.8	4.1	4.6	4.7	4.5	4.4	4.7	4.7	4.6
15 April	13.0	13.7	13.7	13.5	12.9	14.2	14.3	13.8	4.1	4.6	4.7	4.5	4.4	4.7	4.7	4.6
Mean (A)	13.0	13.7	13.7		12.9	14.2	14.3		4.1	4.6	4.7		4.5	4.7	4.7	
L.S.D$_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	NS	0.5		NS	NS	0.5		NS	NS	0.02		NS	NS	0.02		NS
	Non-reducing sugars (%)								Total acidity (%)							
15 February	8.9	9.1	9.0	9.0	8.7	9.6	9.6	9.3	0.310	0.271	0.267	0.283	0.311	0.260	0.259	0.277
15 March	8.9	9.1	9.0	9.0	8.5	9.5	9.6	9.2	0.310	0.270	0.267	0.282	0.311	0.260	0.259	0.277
15 April	8.9	9.1	9.0	9.0	8.5	9.5	9.6	9.2	0.311	0.270	0.268	0.283	0.311	0.260	0.259	0.277
Mean (A)	8.9	9.1	9.0		8.6	9.5	9.6		0.310	0.270	0.267		0.311	0.260	0.259	
L.S.D$_{0.05}$	A	B		AB	A	B		AB	A	B		AB	A	B		AB
	NS	0.03		NS	NS	0.03		NS	NS	0.011		NS	NS	0.012		NS

A, B and AB represent LSD value time of planting (A), plant densities (B) and time of planting×plant densities (A×B), respectively, NS: Non significant

percentage of total acidity did not alter significantly with varying dates of planting. Varying plant densities significantly was followed by changing in chemical characteristics of the fruits. Planting densities (4×4 m apart with three suckers per hole) gave the best results with regard to fruit quality such as starch (1.38 and 1.44%) and TSS (19.5 and 20.0%) while total sugar were (13.7 and 14.3%). No significant differences on fruit quality were observed between wider and medium spacing (4×4) and (3×3) with mother plants 250 and 444 and 750 and 888 first rations, respectively. At the same time the lowest values and significant differences on starch, (1.31 and 1.36%), total soluble solids, (18.5 and 18.8%) and total sugar (13.0 and 12.9%), furthermore reducing and non-reducing sugars percentage of accompanied with high total acidity percentage of (0.310 and 0.311) that observed with closer spacing (2×2 m apart with one suckers per hole). The studied interaction failed to show significant effect on the fruit quality during both seasons.

These results of plant densities are in harmony with those obtained by Reddy (1991); Robinson *et al.* (1994); Sayed-Shrenk (2004); Ali (2005); Ghose and Hossain (1992) who recorded higher total sugar and lower acidity with low plant density. On the other hand, Maharana and Das (1996) observed that all chemical characteristics were not affected by plant densities.

Such findings of planting dates are in partial agreement with those obtained by Abd-Allah (1999); Abd-Allah *et al.* (2011) who reported that fruit harvesting from middle March planting recorded the best chemical characteristics, as well as Bauri *et al.* (2002) observed that fruit harvesting from June planting gives the best fruit quality.

CONCLUSION

Planting suckers of Williams banana at the middle of March with high plant population 1000 mother plants and 1000 first ratoons per fad. (2×2 m apart with one suckers per hole) recorded the highest yield per fad. However, to obtain earliness of harvesting with improving quality of finger. It was likely to cultivate Williams banana at the middle of March with planting densities (3×3 m apart and leaving two suckers per hole) which produces satisfactory yield productivity and qualitatively with early of harvesting dates.

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