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Comparative performance of two oil palm varieties (Deli x AVROS and Deli x Ghana) planted at different densities in two locations

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Abstract

Two density experiments using Deli x AVROS and Deli x Ghana were planted in 1990 at two localities in Costa Rica: Coto (South Pacific) and Quepos (Central Pacific, drier area with higher solar radiation than in Coto). In both sites, density treatments were arranged in a 'fan' pattern ranging from 98 to 231 palms/ha. Vegetative growth and yield components were recorded. Annual average yield (bunch weight) per palm and yield (FFB) per hectare was higher in DxA in Coto, but not in Quepos; where DxG performed better. The highest annual yields per palm were obtained within a range of densities between 70 and 139 palms/ha during the first eight years of production. The best yields (FFB) per hectare (average of years 5 to 10) were obtained with 139 palms/ha in DxA and 164 palms in DxG.

The first growth variable that seemed to be affected by interplant competition with increasing plant density was leaf length (increasing), later, a reduction in leaf emission rate was observed (around the seventh year). Stem height was affected only in adult palms (10 or more years).

Introduction

Variable density experiments in oil palm were proposed by Goh (1977), where the use of plots of different size with the same number of plants has the advantage of a reduction in land and costs when compared with block designs. The main disadvantage of this arrangement of plots is that it is systematic, so no regular variance analysis can be conducted. However, this author also described an analysis procedure to select, between several regression equations, the best density related with maximum yield (Goh, 1982). This analysis was then complemented with a graphical interpretation of the results in order to select the treatment with maximum total yields.

Smith, Donough and Corley (1996) used similar procedures to interpret the results of a density experiment in clones with different canopy characteristics. They found that rachis length and leaf area index could be used as indicators for optimum density. Donough and Kwan (1991) compared the performance of several varieties planted at different densities in two localities, and found an interaction site by variety. They also suggested that total oil produced per area could be a better indicator of the effects of planting density, since fruit to bunch ratio increased with density, which conducted to an increase in the amount of oil produced per unit area within certain range of densities. Also Breure (1982) showed, in a density x fertilizer trial, that rachis length and leaf production were affected by planting density five years after planting.

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This paper compares the performance of two commercial oil palm varieties (Deli x AVROS and Deli x Ghana) planted at different densities (systematic fan arrangement) in two localities with different environmental conditions (South and Central Pacific of Costa Rica).

Materials and methods

Two density experiments using the varieties Deli x AVROS (DxA) and Deli x Ghana (DxG) were planted in Costa Rica in June 1990 in Coto (South Pacific) and Quepos (Central Pacific coast). In both cases, the densities evaluated covered a range from 98 to 231 palms per hectare; even though the total density range varied from 70 to 326 palms per hectare, but these extreme densities were used as border plots. In Coto, there were three six-palm plots for each variety (total of 18 palms for each density and variety). In Quepos, four plots were planted for each variety (24 palms for each variety and density).

The mean annual rainfall in Coto is 3,930 mm, with only two months with rainfall below 100 mm. Under these conditions there is no water deficit or it is very mild in some years. Mean monthly temperatures are within a suitable range for oil palm cultivation (minimum 20-22 °C and maximum 31-34 °C). In this locality solar radiation is below optimal range (<15 Mj/m^2) for 4 to 6 months. In Quepos, total annual rainfall is similar (3,674 mm), but there is a dry season from December to April, with total water deficit of around 400 mm. Mean monthly temperatures vary from a minimum of 23 °C to a maximum of 31 °C.

Yield was recorded during nine (Coto) and eight years (Quepos). Vegetative growth (leaf length and trunk height) was recorded at 76 (Quepos) and 80 (Coto) months after planting to compare both localities; but in Coto growth was also evaluated at 35, 83 and 133 months after planting. Bunch components were determined from about 50 bunches from each density in Coto, when palms were ten years old.

Results and discussion

Yield

The average annual yield per palm for three density ranges was used to facilitate the interpretation of the results: 1) 'low' to 'normal' densities were those varying from 98 to 164 palms/ha, 2) 'high densities' were those varying from 164 to 231 palms/ha, and 3) 'the total range of densities' covered from 98 to 231 palms/ha (Table 1).

DxA, a fast growing variety, performed better at low densities when planted in the Coto locality (less solar radiation). The average annual yield per palm in Coto was higher in D x A (124.5 kg FFB) when compared with D x G (103.7 kg). However, a different situation was observed in Quepos (drier area with higher solar radiation), where annual yield per palm in Ghana (129.7 kg) was higher compared with AVROS (119.4 kg). Yield per palm for DxA was similar in both localities, but DxG performed better in Quepos, indicating, perhaps, its higher tolerance to water deficit. Figure 1shows the reduction in yield per palm as plant density increased.

Table 1. FFB yield per palm in two oil palm varieties planted in two locations at several densities (average of 9 and 8 years in Coto and Quepos, respectively)

Density	Yield (kg/palm/year)			
	Coto		Quepos	
	AVROS	Ghana	AVROS	Ghana
98	164.0	132.1	163.3	176.0
117	160.4	129.5	144.1	143.0
139	139.0	108.7	130.9	147.5
164	119.2	100.4	109.1	117.8
195	96.3	81.2	86.2	101.6
231	68.0	70.5	52.5	92.2
R^2	*0.995*	*0.979*	*0.983*	*0.945*
Average	124.5	103.7	119.4	129.7
Low densities	145.7	117.7	136.9	146.1
High densities	94.5	84.0	92.6	103.9

Low densities: between 98 and 164 palms/ha
High densities: between 164 and 231 palms/ha

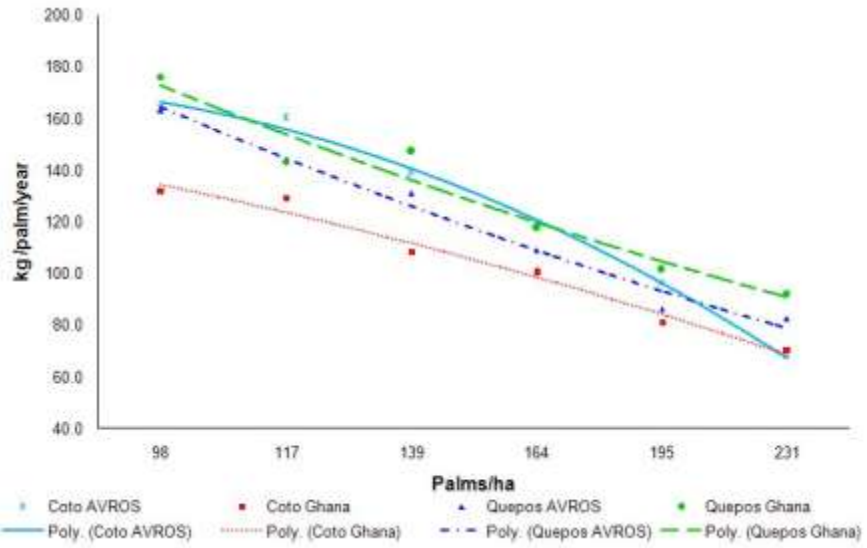

Fig. 1. *FFB per palm in two varieties planted at increasing densities at two sites (Coto and Quepos)*

Optimum density for best yields according to palm age. This was estimated by determining the maximum yield (per palm and per hectare) using mobile means for three years. During the

first ten years, the maximum yield per palm was recorded at lower densities in Coto when compared with Quepos (70 to 83 palms/ha in Coto vs. 98 palms/ha in Quepos), which was expected for the most vigorous growth of DxA (Table 2).

Table 2. Optimum density for best yields in two varieties planted at increasing densities in two locations

		Optimum density/year - years after planting								Average (years)
		3	4	5	6	7	8	9	10	5 to 10
Kg/palm/year										
Coto	AVROS	117	117	83	83	83	70	98	70	83
	Ghana	98	70	70	70	70	70	70	70	70
Quepos	AVROS	139	98	98	98	98	98	98	98	98
	Ghana	139	98	98	98	98	98	98	98	98
Yield (t/ha)										
Coto	AVROS	326	326	164	139	164	139	98	164	139
	Ghana	326	326	164	164	164	164	195	195	164
Quepos	AVROS	326	326	231	231	139	117	117	117	164
	Ghana	326	231	231	231	329	326	139	164	231

* Average estimated after year 5 when competition for light between palms began. Data adjusted to the nearest evaluated density

Best average FFB yields/ha/year (palms from five to 10 years old) were obtained in Quepos at higher densities than in Coto (164 to 231 palms/ha in Quepos vs. 139 to 164 in Coto). In both locations, the optimum yield for DxG was obtained at the highest densities (Table 2).

It was apparent that both varieties could have been planted at higher densities in Quepos in order to obtain the highest yields per hectare. Considering this, the optimum densities to reach the best yields in Coto were 139 palms/ha for DxA and 164 for DxG; which agreed with the present knowledge on the behavior of these two varieties (Breure, 2007). However, other factors besides palm density could have also affected yields (soil types, fertilization practices, rainfall, solar radiation…) but they were not considered in the present analysis.

Vegetative growth and bunch composition

When palms were about six years of age, leaf length was shorter in palms planted at the lower densities, but trunk height had not been apparently affected yet. The difference in leaf length between DxA and DxG was larger in Coto (108 cm) than in Quepos (20 cm). A faster trunk growth of DxA in Coto was expected considering a much lower solar radiation in this locality. However, in Quepos, water deficit seemed to had adversely affected growth in DxA, and no clear differences were noted between the two varieties (Table 3).

Table 3. Stem height and leaf length of two varieties planted at different densities in two localities (Coto:80 months old; Quepos: 76 months old)

Density	Trunk height (cm)				Leaf length (cm)					
	Coto		Quepos		Coto			Quepos		
	AVROS	Ghana	AVROS	Ghana	AVROS	Ghana	dif	AVROS	Ghana	dif
98	238	197	253	271	687	597	90	667	689	-22
117	250	194	250	276	723	632	91	682	692	-10
139	250	209	240	266	753	635	118	690	713	-23
164	262	196	257	263	761	649	112	686	717	-31
195	265	203	251	277	776	658	118	706	732	-26
231	229	200	247	281	824	705	119	734	743	-9
Average	249	200	250	272	754	646	108	694	714	-20

Leaf emission rate was higher in Quepos (28-29 leaves/year vs. 21-24 in Coto). The magnitude of this variable decreased as plant density increased in Coto, but not in Quepos (Table 4).

Table 4. Leaf production rate of two varieties planted at different densities in two locations (Coto: 80 months old: Quepos: 76 months old)

Density	Leaves produced /year			
	Coto		Quepos	
	AVROS	Ghana	AVROS	Ghana
98	27	22	30	31
117	25	21	30	29
139	24	20	29	28
164	23	22	30	27
195	23	22	27	29
231	23	19	26	26
Average	*24*	*21*	*29*	*28*

As seen in Coto, trunk height became an indicator of interplant competition only when palms reached maturity (Fig. 2). However, leaf length showed clear signs of light competition even in rather young palms when planted at higher densities. For the fast growing variety DxA, leaf length was 13-21 % shorter in palms planted at 98 palms/hectare, when compared to the density of 231 palms/ha. For DxG, light competition was less evident (leaves 10 to 16% shorter) (Table 5, Fig. 3).

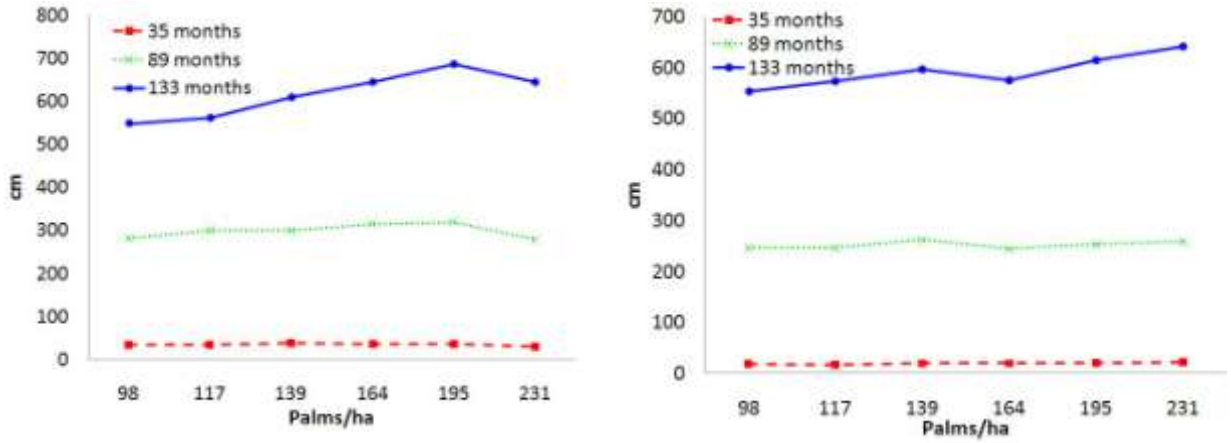

Fig. 2. *Trunk height (cm) at different ages in Deli x AVROS (Left) and Deli x Ghana planted at increasing densities in Coto, Costa Rica*

Table 5. Relative change in leaf length in Deli x AVROS and Deli x Ghana planted at different densities and evaluated at three periods*

Density	Months after planting					
	Deli x AVROS			Deli x Ghana		
	35	89	133	35	89	133
117	1.04	1.05	1.03	1.04	1.06	1.03
139	1.08	1.08	1.09	1.04	1.08	1.03
164	1.09	1.12	1.11	1.03	1.09	1.04
195	1.07	1.13	1.13	1.07	1.11	1.07
231	1.13	1.21	1.21	1.10	1.16	1.10

* % change over data obtained at 98 palms/hectare

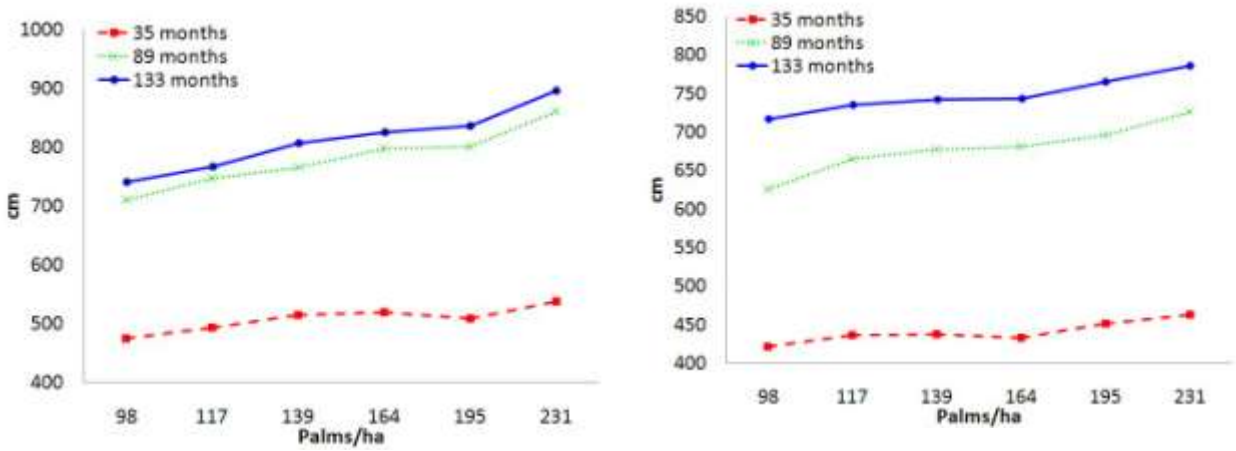

Fig. 3. *Leaf length (cm) at different ages in Deli x AVROS (left) and Deli x Ghana planted at increasing densities in Coto, Costa Rica.*

The variety Deli x Ghana showed a higher oil to bunch ratio, which was independent of plant density. Fuit set increased with palm density (Table 6), which could indicate a more favorable environment for pollination as suggested by Donough and Kwan (1991). Breure et al (1990) also indicated that the pollinating weevils were more active in the cool and shaded conditions prevalent at higher densities.

Table 6. Bunch components for two varieties planted at increasing densities in Coto, Costa Rica

Density	Fertile fruit to bunch (%)	Total fruit to bunch (%)	Mesocarp to fruit (%)	Kernel to fruit (%)	Oil to mesocarp (%)	Oil to bunch (%)
Deli x AVROS						
98	64.2	65.2	78.8	10.7	47.0	24.1
117	65.7	68.1	80.0	9.5	43.3	23.5
139	68.1	69.3	82.1	9.3	47.9	27.1
164	65.3	67.2	81.8	9.2	48.9	26.8
195	65.7	67.0	80.1	9.7	45.4	24.2
Average	65.9	67.6	80.9	9.6	47.3	25.8
Deli x Ghana						
98	68.4	69.4	78.0	8.7	46.2	25.0
117	69.9	70.7	83.0	6.3	49.5	29.1
139	69.7	71.2	80.5	7.4	48.6	27.9
164	71.2	71.5	79.0	8.1	46.1	26.1
195	71.8	72.7	77.6	8.1	15.2	25.6
Average	70.7	71.5	79.5	7.8	46.9	26.7

Conclusions

The variety Deli x Ghana showed some important advantages over the traditional variety Deli x AVROS, especially more tolerance to light competition (can be planted at higher densities due to its shorter leaves as seen in Coto), tolerance to drought (performed better in an area with high water deficit) and has a higher oil content.

Best economical yields could be obtained over a range of planting densities; but, for a vigorous variety like DxA, best yields were obtained at lower densities when planted in a site like the South Pacific coast of Costa Rica were solar radiation could be a limiting factor. The standard density of 142 or less palms per hectare can be considered acceptable for DxA in this environment. For a less vigorous variety like DxG, with shorter leaves, planting density can be increased to 160 plants per hectare.

The first vegetative variable that seemed to be affected by interplant competition with increasing plant density was leaf length (increased).

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