GROWTH AND FIBER MORPHOLOGY OF ABACA (*Musa textilis* Nee) RATOONS AS INFLUENCED BY PLANT DENSITY AND NITROGEN LEVEL

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ABSTRACT

An old abaca plantation was subjected to butcher harvest as a rejuvenation process. The subsequent ratoons were evaluated in terms of growth and fiber dimensions as influenced by plant density and nitrogen level. Replants served as checks in determining the merits of ratooning.

Ratoons emerged approximately 13 days earlier, had more rapid growth and higher dry matter yield of stalk and leaves than the replants. These horticultural characteristics were not significantly affected by plant density and nitrogen fertilizer application after a 12-month period.

Leaf N content significantly increased with increased N fertilizer application during the sixth month but not after 12 months. It was not influenced by plant density.

Fiber cellular dimensions were not affected by the application of 0, 50, 100 and 200 kg N/ha as well as by plant density. However, fiber dimensions of ratoons at any density were bigger than those of replants.

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KEY WORDS: Abaca ratoons. Replants. Plant density. Nitrogen level. Growth. Fiber cell dimensions.

INTRODUCTION

Existing old abaca plantations decline in their productivity period due to nutrient exhaustion caused by continuous cropping and its subsequent production of floating suckers or "taguiltils". Once these conditions occur, rejuvenation by butchering old plants may be employed to allow dormant but vigorous suckers to arise. Ratooning the subsequent growth is regarded by Plucknett et al. (1970) to be very important in abaca growing since the crop exists in the field and is harvested over many years.

Ratooning in abaca has long been known to man, i.e. since new shoots which follow the cutting of the crop plant at harvest were observed to produce a new crop without replanting. However, depletion of nutrient supply during ratooning puts a limit to production. Hence, modifications like controlling the number of suckers to be allowed to grow after butchering, and nitrogen application are expected to increase productivity of old fields.

Considering production-linked variables among other alternatives, abaca fibers can be tailored according to purpose, whether for pulp and paper production or cordage, based on the interaction of plant density and nitrogen application in relation to morphological dimensions of the fiber cells (Tabora, 1978). Devlin (1975) stipulated that the size and shape of a plant are largely due to the number, morphology and arrangement of its cells. Hence, it is speculated that since the general stand of the plant is affected by plant density and application of fertilizer, therefore, cells comprising the parts of the plant will also be affected. This study was thus conducted to determine the effects of plant density and nitrogen level on the growth, dry matter yield and fiber cellular dimensions of abaca ratoons and to evaluate the merits of ratooning as a rejuvenation process in old abaca plantations.

MATERIALS AND METHODS

An old (more than 15 years old) abaca plantation with an area of 3,840 m^2 excluding 2 m alleyways between plots was selected at the Abuyog Experimental Station, Abuyog, Leyte. After butchering old existing stalks close to the ground in the plantation, 60 experimental units each measuring 8 m x 8 m were laid out using the split plot arranged in randomized complete block (RCBD) design with three replications.

The treatments were as follows:

Plant Density Levels (Main Plots)

- S_1 - Replants (no desuckering) - at 6,000-8,000/ha
- S_2 - Unlimited ratoons (no desuckering) at 14,000-17,000/ha
- S_3 - Ratoons at 5,000/ha
- S_4 - Ratoons at 7,500/ha
- S_5 - Ratoons at 10,000/ha

Nitrogen Levels (Subplots)

- N_1 - 0 kg N/ha
- N_2 - 50 kg N/ha
- N_3 - 100 kg N/ha
- N_4 - 200 kg N/ha

Upon ratoon emergence, plant density was controlled by desuckering. Equidistancing of ratoons was observed although irregular. The materials used for replants were the dug corms which were spaced 2 m x 2 m like the ratoons.

Nitrogen in the form of urea was applied at 3-month intervals. Phosphorus and potassium were not applied. Underbrushing, ring weeding and removal of dried leaves were employed uniformly.

Leaf and stalk samples were collected at 6 and 12 months after emergence of replants and ratoons for the different observations. For the fiber morphological study, 360 samples (20 treatments x 3 replications x 3 portions where samples were taken x 2 harvests) were fixed in FAA (formalin + acetic acid + alcohol). Maceration was done by boiling samples in a test tube with H_2O_2 and glacial acetic acid in a water bath. Using the macerated samples, cell length and diameter, lumen width and wall thickness were measured. Sectioning by paraffin method was also performed to determine the cross-sectional area of mechanical fiber bundles.

RESULTS AND DISCUSSION

Emergence and Number of Suckers

In general, ratoons emerged approximately 13 days earlier than replants after butcher harvest of old abaca plants. The delayed emergence of suckers from replants is attributed to the stress on the corms caused by their being dug and split into smaller seedpieces.

When suckers were not controlled, ratoons had more than twice as much suckers as the replants (Table 1). The early emergence and production of numerous ratoon suckers after butcher harvest can be attributed to the phenomena of apical dominance, i.e. the shoot apex regulates the growth and development of lateral buds; and compensatory growth, i.e. the removal of the leaves and stem stimulates the growth of other plant parts. Thus, it is deduced that the dormant buds from the undisturbed corms were induced to emerge to compensate for the removed aerial portions after butcher harvest.

Stalk Height

Stalk height was not influenced by the N fertilizer application at

Table 1. Average number of suckers from control abaca ratoons and replants (without desuckering) at 6 and 12 months after emergence (mean of three replications).

Treatment	Average Number of Suckers	
	6th month	12th month
Replants	6,328	8,711
Ratoons	14,648	17,578

various levels (Table 2). Plant density also did not generally affect stalk height. Although replants were significantly shortest (149 cm), their stalk height did not significantly differ from that of ratoons at a density of 5,000 plants/ha. Interaction effects, however, showed that unfertilized replants were the shortest (135 cm) and ratoons at a density of 7,500 plants/ha and applied with 100 kg N/ha were the longest (194 cm).

Regardless of plant density and N application, ratoons developed faster than replants because of the earlier emergence of the former. This can be attributed to the ready formed root system in ratoons which was also observed by Plucknett et al. (1970). Faster growth suggests earlier attainment of harvestable stalk height. This implies possible early harvest of ratoons on the basis of stalk height due to a shortened growth cycle in addition to savings in the cost of plant care during the early phases of seedling growth.

Table 2. Effect of plant density and N level on the stalk height of abaca after 12 months.

	Plant Height (cm)[1]				
	Nitrogen Level (kg/ha)				
Plant Density	**0**	**50**	**100**	**200**	**Mean[1]**
Replants (6,000-8,000/ha)	135b	151ab	156ab	155ab	149b
Unlimited ratoons (14,000-17,000/ha)	180ab	174ab	183ab	181ab	179a
Ratoons at 5,000/ha	171ab	171ab	168ab	172ab	171ab
Ratoons at 7,500/ha	158ab	181ab	194a	176ab	177a
Ratoons at 10,000/ha	171ab	169ab	187ab	183ab	178a
Mean[1]	163a	169a	178a	174a	

[1]Interaction, plant density or nitrogen level means followed by a common letter are not significantly different at 5% level, DMRT.

Dry Matter Yield

The dry matter yield of stalks and leaves was not affected by nitrogen application at 6 and 12 months after emergence (Table 3). The replants had the lowest mean dry matter yield of 89 and 333 g at 6 and 12 months after emergence, respectively. During the sixth month, the highest mean dry matter yield (273 g) was obtained from the unlimited ratoons and this was significantly higher than that of ratoons at 10,000/ha (208 g) and that of the replants (89 g). It was observed that during the twelfth month, there were no significant differences among the various densities of ratoons.

N Content of the Leaf Tissue

The leaf tissues of replants and ratoons at various densities had about the same N content at 6 and 12 months after emergence (Table 4). However, an increased rate of N application resulted in an increased N content of the leaf tissue on the sixth month. The addition of 200 kg N/ha brought about the highest N content (2.98%). This agrees with the findings of Bucad (1982) that at 2 months after nitrogen application, leaf N was markedly influenced by the amount of N given to the plant. Smith (1962) claimed that suitable application of an element, which is shown by tissue analysis to be present in adequate amounts, causes both an increase in tissue concentration of that element and a growth response. It is therefore possible that on the sixth month, the total amount of N fertilizer applied have increased the nitrogen concentration of the leaf tissues.

On the twelfth month, the leaf N content was not influenced by N fertilizer application. This could be attributed to the utilization of N for increased dry matter production. In banana, Twyford and Walmsley (1974) noted that N concentration tended to decrease with age up to shooting (first appearance of flower buds) after which it changed very little in most vegetative parts. This denotes that leaf N is high at early stages but low at advanced stages, e.g. during flowering stage. At this stage, N is apparently diverted to flower and fruit production such that leaf N is low.

Fiber Cellular Dimensions

The fiber cellular dimensions were not affected by the application of N fertilizer but were influenced by plant density to some extent. However, it is not known whether these differences are due to plant density or to the kind of plant material used. It was observed that replants generally had significantly shorter fiber cells (Table 5), narrower cell diameter (Table 6) and smaller mechanical fiber bundles as measured from the cross-section (Table 7) than the ratoons at the sixth and twelfth month after emergence.

On the twelfth month, the grand mean cell lengths of the outer, middle and inner leaf sheaths were 4.73, 5.06 and 5.35 mm, respectively (Table 5). Thus, the outer sheaths

Table 3. Effect of plant density and N level on the dry matter yield of abaca stalks and leaves at 6 and 12 months after emergence.

Plant Density	Plant Height (cm)[1]				
	Nitrogen Level (kg/ha)				
	0	50	100	200	Mean[1]
6th month:					
Replants (6,000-8,000/ha)	58 c	91 de	91 de	115 cde	89 c
Unlimited ratoons (14,000-17,000/ha)	305 a	211 a-d	282 ab	295 a	273 a
Ratoons at 5,000/ha	221 abc	218 abc	233 abc	307 a	245 ab
Ratoons at 7,500/ha	243 ab	284 ab	276 ab	235 abc	260 ab
Ratoons at 10,000/ha	161 b-e	217 abc	208 a-d	245 ab	208 b
Mean[1]	198 a	204 a	218 a	239 a	
12th month:					
Replants (6,000-8,000/ha)	267 d	278 d	433 bcd	356 cd	333 b
Unlimited ratoons (14,000-17,000/ha)	589 abc	489 a-d	678 ab	656 abc	603 a
Ratoons at 5,000/ha	622 abc	678 ab	556 a-d	600 abc	614 a
Ratoons at 7,500/ha	467 bcd	678 ab	778 a	589 abc	628 a
Ratoons at 10,000/ha	633 abc	511 a-d	722 ab	656 abc	631 a
Mean[1]	516 a	527 a	633 a	571 a	

[1]Interaction, plant density and nitrogen level means followed by a common letter are not significantly different at 5% level, DMRT.

Table 4. Effect of plant density and N level on the N content of abaca leaf tissues at 6 and 12 months after emergence.

Plant Density	Nitrogen Content (%)[1]				
	Nitrogen Level (kg/ha)				
	0	50	100	200	Mean[1]
6th month:					
Replants (6,000-8,000/ha)	2.85 a-e	2.59 c-f	2.97 abc	2.98 abc	2.85 a
Unlimited ratoons (14,000-17,000/ha)	2.52 ef	2.80 a-e	2.88 a-d	3.11 ab	2.83 a
Ratoons at 5,000/ha	2.34 f	3.00 ab	2.99 ab	3.21 a	2.89 a
Ratoons at 7,500/ha	2.82 a-e	2.54 def	2.78 b-e	2.78 b-e	2.73 a
Ratoons at 10,000/ha	2.47 ef	2.83 a-e	2.88 a-d	2.79 b-e	2.74 a
Mean[1]	2.60 c	2.75 b	2.90 ab	2.98 a	
12th month:					
Replants (6,000-8,000/ha)	2.41ab	2.40 ab	2.62 ab	2.46 ab	2.47 a
Unlimited ratoons (14,000-17,000/ha)	3.52 a	2.17 b	2.09 b	2.34 ab	2.53 a
Ratoons at 5,000/ha	2.48 ab	2.56 ab	2.87 ab	2.31 ab	2.56 a
Ratoons at 7,500/ha	2.56 ab	2.48 ab	2.29 ab	2.70 ab	2.51 a
Ratoons at 10,000/ha	1.81 b	2.39 ab	2.56 ab	2.53 ab	2.32 a
Mean[1]	2.56 a	2.40 a	2.84 a	2.47 a	

[1]Interaction, plant density and nitrogen level means followed by a common letter are not significantly different at 5% level, DMRT.

Table 5. Mean fiber cell length from the outer, middle and inner leaf sheaths of abaca replants/ratoons at 6 and 12 months after emergence.

Plant Density	Fiber Cell Length (mm)					
	Portion of the Leaf Sheath/Month					
	Outer		Middle		Inner	
	6th	12th	6th	12th	6th	12th
Replants (6,000-8,000/ha)	3.50 b	4.50 b	3.55 b	4.71 b	3.56 b	5.00 b
Unlimited ratoons (14,000-17,000/ha)	3.95 a	4.94 a	4.00 a	5.16 ab	4.09 a	5.48 a
Ratoons at 5,000/ha	3.79 a	4.75 ab	3.96 a	5.00 ab	4.03 a	5.45 a
Ratoons at 7,500/ha	3.90 a	4.72 ab	4.18 a	5.24 a	4.03 a	5.45 a
Ratoons at 10,000/ha	3.92 a	4.75 ab	4.19 a	5.22 a	4.05 a	5.39 a
Mean	3.81	4.73	3.98	5.06	3.95	5.35
C. V. (%)	8.37	9.64	8.31	10.56	8.78	8.17

In a column, means followed by a common letter are not significantly different at 5% level, DMRT.

Table 6. Mean fiber cell diameter from the outer, middle and inner leaf sheaths of abaca replants/ratoons at 6 and 12 months after emergence.

Plant Density	Fiber Cell Diameter (μ)					
	Portion of the Leaf Sheath/Month					
	Outer		Middle		Inner	
	6th	12th	6th	12th	6th	12th
Replants (6,000-8,000/ha)	32.29 b	44.09 b	39.02 b	47.16 a	40.46 b	47.11 a
Unlimited ratoons (14,000-17,000/ha)	41.63 ab	46.59 ab	42.38 a	46.66 a	43.72 a	48.23 a
Ratoons at 5,000/ha	42.66 a	47.61 a	43.23 a	49.14 a	44.47 a	49.61 a
Ratoons at 7,500/ha	41.92 ab	47.78 a	43.02 a	47.32 a	43.37 a	49.52 a
Ratoons at 10,000/ha	42.64 a	45.61 a	43.83 a	48.48 a	43.83 a	48.89 a
Mean	41.57	46.33	42.10	47.75	43.16	48.67
C.V. (%)	7.39	7.44	6.65	6.55	7.02	5.84

In a column, means followed by a common letter are not significantly different at 5% level, DMRT.

Table 7. Mean cross-sectional area of the mechanical fiber bundles from the outer, middle and inner leaf sheaths of abaca replants/ratoons at 6 and 12 months after emergence.

Plant Density	Cross Sectional Area (μ^2 x 1000)					
	Portion of the Leaf Sheath/Month					
	Outer		Middle		Inner	
	6th	12th	6th	12th	6th	12th
Replants (6,000-8,000/ha)	158 c	202 b	173 b	206 b	173 b	220 c
Unlimited ratoons (14,000-17,000/ha)	213 b	249 a	249 a	236 a	240 a	237 bc
Ratoons at 5,000/ha	249 a	262 a	249 a	254 a	262 a	274 a
Ratoons at 7,500/ha	214 b	257 a	244 a	247 a	254 a	258 ab
Ratoons at 10,000/ha	207 b	238 a	234 a	236 a	239 a	251 ab
Mean	208	242	229	235	233	248
C. V. (%)	15.71	14.65	15.20	12.25	16.06	14.26

In a column, means followed by a common letter are not significantly different at 5% level, DMRT.

had the shortest fiber cells followed by the middle while the inner sheaths had the longest fiber cells. This agrees with the data obtained by Ramos (1971), Flor (1974) and Alcober (1981).

The fiber cell diameter showed the same trend as that of cell length, i.e. the outer sheaths had the smallest diameter followed by the middle while the inner sheaths had the biggest (Table 6). The same is true with lumen diameter (Table 8) especially during the twelfth month. However, the data on cell wall thickness (Table 9) showed that on the twelfth month, the inner sheaths had the thinnest cell walls (8.08 μ), followed by the middle leaf sheath cells (8.24 μ) while the thickest were those from the outer sheaths (8.41 μ). This observation conforms with those of Tabora (1976), Albano (1952) and Tirona (1932) that the younger leaf sheaths have the thinnest walled fiber cells and are expected to register low tensile strength due to incomplete development.

Larger fiber strands or fiber bundles measured in terms of the cross-sectional area of the mechanical fiber bundles suggest greater fiber strength. Table 7 shows that replants had the smallest mechanical fiber bundles from the outer, middle and inner leaf sheaths at 6 and 12 months after emergence. Hence, it is expected that fibers of replants are not as strong as those of ratoons.

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Table 8. Mean lumen diameter from the outer, middle and inner leaf sheaths of abaca replants/ratoons at 6 and 12 months after emergence.

Plant Density	Lumen Diameter (µ)					
	Portion of the Leaf Sheath/Month					
	Outer		Middle		Inner	
	6th	12th	6th	12th	6th	12th
Replants (6,000-8,000/ha)	25.18 a	27.71 b	24.46 a	31.07 a	26.66 a	31.71 a
Unlimited ratoons (14,000-17,000/ha)	24.81 a	29.72 ab	25.19 a	30.38 a	28.93 a	32.16 a
Ratoons at 5,000/ha	26.53 a	30.41 ab	26.70 a	32.39 a	29.13 a	32.98 a
Ratoons at 7,500/ha	26.57 a	30.64 a	27.22 a	30.16 a	28.80 a	32.61 a
Ratoons at 10,000/ha	21.18 a	29.02 ab	25.89 a	31.85 a	29.48 a	33.07 a
Mean	26.05	29.50	25.89	31.17	28.60	32.51
C. V. (%)	12.13	10.54	13.91	7.97	11.62	8.78

In a column, means followed by a common letter are not significantly different at 5% level, DMRT.

Table 9. Mean cell wall thickness of fibers from the outer, middle and inner leaf sheaths of abaca replants/ ratoons at 6 and 12 months after emergence.

Plant Density	Cell Wall Thickness (μ)					
	Portion of the Leaf Sheath/Month					
	Outer		Middle		Inner	
	6th	12th	6th	12th	6th	12th
Replants (6,000-8,000/ha)	7.05 c	8.19 a	7.28 b	8.05 a	6.91 a	7.71 a
Unlimited ratoons (14,000-17,000/ha)	8.42 a	8.43 a	8.60 a	8.14 a	7.36 a	8.04 a
Ratoons at 5,000/ha	7.91 ab	8.58 a	8.23 a	8.37 a	7.65 a	8.30 a
Ratoons at 7,500/ha	7.66 bc	8.57 a	7.90 ab	8.58 a	7.26 a	8.43 a
Ratoons at 10,000/ha	7.72 b	8.28 a	8.46 a	8.08 a	7.16 a	7.90 a
Mean	7.75	8.41	8.09	8.24	7.27 a	8.08
C. V. (%)	9.78	8.34	10.42	10.45	14.17	10.38

In a column, means followed by a common letter are not significantly different at 5% level, DMRT.

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