MORPHOLOGICAL CHARACTERS AND YIELD OF ABACA AND RELATED *MUSA* CLONES IN BAYBAY, LEYTE, PHILIPPINES

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ABSTRACT

Thirty-six clones of abaca and related *Musa* species were studied to determine their morphological characters, fiber yield and recovery, and tensile strength of their fibers; and to evaluate the relative merit of each parameter to fiber yield. The different clones showed wide variation in all the characters evaluated. Generally, clones with many suckers per hill produced more floating suckers. Basal and middle stalk circumference, length and weight of stalks, number of leaf sheaths per stalk, number of suckers and harvestable stalks per hill, and fiber recovery significantly influenced fiber yield.

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KEY WORDS: Abaca. *Musa* species. Clones. Hybrids. Morphological characters. Fiber recovery. Fiber yield. Tensile strength.

INTRODUCTION

One of the most pressing problems plaguing the abaca industry in the Philippines is low productivity. Efforts to increase production output from the current national average of 0.66 tons of fiber per hectare to a current potential of 2.5 tons per hectare (Gonzales, 1976) are imperative.

Selection of high-yielding varieties or hybrids adapted to diverse soil and climatic conditions could undoubtedly usher in increased fiber production. However, yield as a factor in production depends largely on the variety. Moreover; the potential for high yield, disease resistance and drought hardiness of the species are related to its genetic constitution (Tisdale and Nelson, 1975). These are influenced by the environment in which it is grown and the management practices or agricultural techniques employed (Batugal, 1973).

In the Philippines; several abaca varieties, their relatives and many hybrids exist. Brewbaker and Umali (1956) stated that abaca has about 100 different names while Tabora and Carlos (1978) reported no less than 200 abaca varieties throughout the archipelago. Several researchers (Robinson and Johnson, 1953; Gorres, 1955; Pasco, 1957; Bernardo 1957; Brewbaker and Umali, 1956; and Palatino, 1972) have shown that *Musa* cultivars vary in their gross morphological characters. Their fibers also differ in physical and morphological properties.

Data related to the various plant characters particularly fiber properties are the primary concern of plant breeders and producers. Studies on this aspect may be significant in varietal screening, classification and quality evaluation in relation to the varied uses of the fiber. Furthermore, the relative merit of each plant character and fiber property to fiber yield is not fully understood.

This study was conducted to investigate the morphological characters, fiber yield and recovery of 36 selected clones of abaca and related *Musa* species grown in Baybay, Leyte; to determine the tensile strength of their fibers; and to evaluate the relative importance of each parameter to fiber yield.

MATERIALS AND METHODS

Thirty-six clones of abaca and related *Musa* species [32 abaca *(Musa textilis)* cultivars, two abaca hybrids and two *Musa* species related to abaca] from the University of the Philippines at Los Baños, College, Laguna were used in this study.

The seed pieces were planted in the abaca-coconut gene bank of the Visayas State College of Agriculture, Baybay, Leyte. Each clone was planted in two rows which were 2.5 x 2.5 m apart and located between rows of bearing coconut trees (20-25 years old) with plant spacing of 10 x 10 m.

Ten hills or mats from each of the 36 clones were tagged as sample plants. Before each harvesting period, the number of "good" suckers (stalks more than 30 cm tall) and floating suckers or "taguiltils" (suckers that appear poorly growing, chlorotic and with slender stalks) produced per hill or mat was recorded. The floating suckers were removed by cutting their bases close to the ground. All mature harvestable stalks per hill were marked with paint at 20 cm from the ground level to serve as guide to workers on where to cut after tumbling. Another mark was made at the middle portion of each stalk for the sample number.

Harvesting was done every 4 months. The first harvest was done when the abaca plants were 35 months old. However, only the data collected during the second, third and fourth harvests were analyzed because the stalks of some abaca cultivars were already overmature during the first harvest.

The length and circumference of tumbled stalks were determined using a tape measure and a steel tape. All tumbled stalks were individually weighed after cutting their terminal portions at the point of divergence of the two oldest green petioles. After weighing, each stalk was tuxied following the "loknit" method (Anonymous, undated). The tuxies extracted from each stalk were bundled and labeled with a plastic strip to indicate name of clone and sample number.

Two stalks were randomly collected from each clone for tensile strength determination. The tuxies were classified as outer, middle and inner depending on the position in the stalk of the leaf sheath from which they were extracted. Classification was based on similarity in color as is usually done by abaca farmers and other researchers in conducting experiments. Each group of tuxy per clone was bundled and labeled accordingly.

A spindle stripping machine with a non-serrated knife and run by a waterwheel was used in extracting the fibers. Each group of tuxy per stalk was stripped and the fibers were bundled separately. The stripped fibers were sundried for 2 days by hanging them on horizontally raised bamboo poles. However during rainy days, the fibers were air-dried in the shedhouse.

The dried fibers were hung inside the shedhouse for 5 days to stabilize the moisture content. These were then weighed on per stalk basis using a triple-beam balance. Ten sample fibers (each approximately 20 cm long and weighing 0.3 g) representing the outer, middle and inner leaf sheaths per stalk were obtained for tensile strength determination. These were taken about 1 to 2 feet from the base of each fiber bundle. The fibers were tested for breaking load using the Shimadzu tensile tester machine.

Ten 20-cm long samples (10 fiber strands per group) were weighed in a Mettler analytical balance for tensile strength determination. The strength was computed using the formula of Botkin et al. (1943) as follows:

$$\text{Tensile strength (km)} = \frac{\text{Breaking load of the fiber (kg)}}{\text{Wt. of fiber (g)/Length of fiber (m)}}$$

RESULTS AND DISCUSSION

Horticultural Characters

The number of suckers and harvestable stalks per hill produced by the 36 clones differed significantly (Table 1). Abaca clones 'Ginabaki' and 'Canton' obtained the highest and lowest values, respectively. The superiority of 'Ginabaki' in terms of the aforementioned characters is noteworthy. This cultivar as well as 'Bulao Luno' seems more promising than the 10 clones evaluated by Oyardo (1974a) which produced an average of 1.37 suckers per hill. However, the number of

Table 1. Number of suckers, floating suckers, and harvestable stalks per hill; and number of leaf sheaths of different abaca cultivars, hybrids and *Musa* species. (Means of three harvests)

Clone	Number Per Hill			Number of Leaf Sheaths per Stalk
	Suckers	Floating Suckers	Harvestable Stalks	
Abaca Cultivars				
Ginabaki	22.00	2.21	2.13	20.50
Bulao Luno	19.06	2.40	2.10	15.52
Sinalampago	15.53	1.23	1.97	14.10
GAES No. 1	14.30	2.13	1.96	12.61
Binagakay	14.30	2.13	1.96	20.06
Casilihon	14.40	1.33	1.90	17.96
Linawaan	18.70	2.23	1.76	16.52
Del Monte Pula	13.23	1.83	1.66	18.85
Baunan	14.76	1.80	1.60	18.85
Inosa	9.00	0.63	1.60	20.33
Canarahon	14.30	0.93	1.53	16.74
Amokid	17.76	2.43	1.50	17.21
Bagakayon Kidit	16.00	1.30	1.36	18.10
Minenonga	13.10	0.80	1.33	19.30
Samoro	10.06	1.03	1.26	17.87
Sairaya	9.86	0.73	1.26	18.21
Sugmad Pula	10.93	1.16	1.23	20.78
Samorong Pula	11.60	0.93	1.20	20.50
Samina	13.40	2.10	1.10	10.03
Binongongoran	9.36	1.96	1.06	15.78
Del Monte Puti	8.60	0.40	1.00	20.80
Inagutay	8.23	0.50	1.00	16.43
CES No. 3	8.00	0.53	1.00	18.60
Ogarum	8.40	0.60	0.90	20.09
Lunhan	6.90	0.47	0.90	18.67
Baguisanon Puti	6.16	0.33	0.86	19.88
Puti	9.66	1.03	0.83	12.40
Tangongon	10.73	1.10	0.80	19.77
Libutan	9.10	1.20	0.76	14.96
Layahon	6.83	0.83	0.76	16.35
Lagurhuan	6.76	0.70	0.63	17.30
Tinawagan Puti	10.03	1.50	0.56	20.06
Hybrids				
Pacol x CES No. 3	16.43	1.13	2.00	25.22
Lawaan x Tangongon	14.53	1.60	1.83	20.73
Musa Species				
Tetraploid III	9.90	0.60	0.80	21.29
Canton	5.37	0.53	0.53	20.75
Mean	11.95	1.29	1.22	18.19
HSD .05	3.03	0.89	0.62	3.18
.01	3.47	1.02	0.85	3.65
C.V. (%)	33.47	20.32	47.74	12.99

suckers obtained in this study is comparable to that obtained from the heavy stooling 'Bongolanon' cultivar (Gonzales et al., 1974).

Eighteen abaca cultivars exhibited an average of more than one harvestable stalk per harvest (Table 1). This is fairly good since the peak of production seems not to have been attained yet. PCARR (1977) reported that peak of production in abaca can be attained 4 years after planting. The greater number of harvestable stalks produced by profusely suckering cultivars indicates a strong relationship between production of harvestable stalks and stooling ability of a variety. This observation further suggests that stooling ability could be an important index in selecting a variety with high-yielding potential. Accelerated production of suckers or followers per unit time is important in replenishing harvested stalks and thus, a desirable character of abaca.

Generally, the number of floating suckers produced by a clone depends on the number of suckers in a hill or mat, i.e. clones with many suckers in a hill or mat produced more floating suckers and vice versa. However, cultivars with profuse suckering such as 'Bulao Luno', 'Sinalampago', 'Linawaan' and 'Amokid' produced relatively smaller, shorter and lighter harvestable stalks (Tables 2 and 3). The greater number of floating suckers produced by heavily suckering cultivars might have adversely affected the development of harvestable stalks due to competition with other suckers or followers for nutrients and sunlight (Oyardo, 1974b; Tabora, 1978).

Abaca cultivars 'Puti', 'GAES No. 1', 'Sinalampago', 'Libotan' and 'Samina' produced less than 15 leaf sheaths per stalk. The hybrid 'Pacol x CES No. 3' produced the highest number (25.22) of leaf sheaths per stalk.

Stalk Characters

Stalk length which was measured 20 cm from the ground to the point between the peduncles of the two youngest leaves ranged from 1.48 m in 'Puti' to 3.96 m in 'Tetraploid III' (Table 3). 'Tetraploid III' and five abaca cultivars ('Lagurhuan', 'Minenonga', 'Inosa', 'Samora' and 'Casilihon') possess stalks measuring more than 3 meters. Cultivars with short stalks also have small-sized stalks (Table 2).

Table 3 shows that 'Tetraploid III' did not only possess the longest stalks but also the heaviest stalks (44.51 kg). This was followed by 'Del Monte Puti', 'Lagurhuan' and 'Inosa'. Lighter stalks were observed in 'Puti', 'GAES No. 1' and 'Sinalampago'. Each stalk of the two abaca hybrids weighed more than 21 kg.

The size of stalks could be determined by the number of leaf sheaths. This is supported by the highly significant correlation between the number of leaf sheaths and the basal, middle and top circumference of stalks (Table 4). Bigger stalks with more leaf sheaths produce heavier stalks hence, more

Table 2. Circumference of stalks (base, middle and top) of different abaca cultivars, hybrids and *Musa* species. (Means of three harvests)

Clone	Stalk Circumference (cm)			
	Base	Middle	Top	Mean
Abaca Cultivars				
Del Monte Puti	66.01	50.86	37.33	51.34
Lagurhuan	56.03	42.82	33.68	44.77
Tangongon	54.87	40.07	32.76	42.57
Inosa	56.99	39.57	31.01	42.52
Bagakayon Kidit	54.39	37.65	31.10	41.05
Samoro	52.80	38.75	30.25	40.60
Minenonga	53.02	37.30	30.95	40.43
Tinawagan Puti	50.75	37.82	32.21	40.26
CES No. 3	52.28	38.24	30.20	40.24
Casilihon	52.63	36.39	28.03	39.01
Baguisanon Puti	50.97	36.44	28.93	38.78
Sugmad Pula	49.94	37.30	28.81	38.68
Baunan	50.41	35.38	27.17	37.66
Canarahon	47.97	34.26	30.29	37.51
Sairaya	47.27	35.36	28.66	37.10
Ogarum	47.04	34.50	29.51	37.01
Samorong Pula	46.35	34.36	27.82	36.18
Lunhan	47.51	33.91	25.59	35.67
Inagutay	47.95	32.22	25.78	35.31
Binagakay	45.39	32.72	25.11	34.40
Samina	44.67	31.69	26.74	34.37
Layahon	43.42	31.97	27.65	34.34
Ginabaki	41.63	31:99	25.65	33.06
Del Monte Pula	38.96	28.94	22.61	32.17
Amokid	40.56	30.47	24.86	31.97
Binongongoran	37.18	27.25	24.06	29.50
Bulao Luno	36.23	28.01	22.61	28.95
Linawaan	38.77	26.68	20.53	28.88
Libutan	36.33	26.07	21.78	28.06
Sinalampago	32.69	22.48	19.63	24.94
GAES No. 1	30.00	21.45	19.28	23.58
Puti	25.52	17.84	15.73	19.69
Hybrid				
Pacol x CES No. 3	57.25	41.35	28.57	42.39
Lawaan x Tangongon	52.91	38.55	30.72	40.73
Musa Species				
Tetraploid III	65.74	52.19	38.23	52.05
Canton	48.85	34.56	30.78	38.07
Mean	47.26	34.36	27.62	36.41
HSD .05	11.90	9.29	8.61	
.01	13.63	10.64	9.87	
C.V. (%)	16.37	16.28	13.78	

Table 3. Length and weight of stalks and fiber yield per stalk of different abaca cultivars, hybrids and *Musa* species. (Means of three harvests)

Clone	Stalk Length (m)	Stalk Weight (kg)	Fiber Yield/ Stalk (g)
Abaca Cultivars			
Del Monte Puti	2.91	35.56	406.20
Inosa	3.22	26.89	386.49
Lagurhuan	3.39	28.67	352.77
Baunan	2.79	18.64	310.26
Minenonga	3.26	23.08	309.96
Sugmad Pula	2.87	20.62	266.41
Tangongon	2.88	25.27	234.69
CES No. 3	2.89	23.72	233.42
Tinawagan Puti	2.68	20.90	203.93
Sairaya	2.62	19.62	202.92
Lunhan	2.63	17.84	196.21
Baguisanon Puti	2.95	19.74	189.98
Binagakay	2.68	14.61	188.42
Ogarum	2.42	16.87	179.55
Del Monte Pula	2.79	13.27	179.31
Canarahon	2.33	15.90	177.16
Bagakayon Kidit	2.24	19.25	163.16
Samorong Pula	2.92	17.68	163.15
Casilihon	3.08	21.62	162.73
Samina	2.09	15.05	160.50
Samoro	3.17	15.48	155.18
Linawaan	2.61	10.27	152.50
Ginabaki	2.92	15.68	146.83
Inagutay	2.51	22.71	123.49
Layahon	2.26	11.81	122.03
Binongongoran	1.94	9.36	106.93
Bulao Luno	2.61	10.88	100.09
Libutan	2.24	8.91	81.71
Amokid	2.44	12.75	77.75
Sinalampago	1.85	5.98	68.80
GAES No. 1	1.67	5.44	57.58
Puti	1.48	3.23	36.32
Hybrids			
Lawaan x Tangongon	2.64	21.39	270.63
Pacol x CES No. 3	2.69	21.86	77.77
Musa Species			
Tetraploid III	3.96	44.51	105.82
Canton	2.21	16.01	49.79
Mean	2.56	18.08	176.05
HSD .05	0.69	10.65	99.49
.01	0.78	12.20	113.98
C.V. (%)	13.78	36.38	40.26

Table 4. Matrix of intercorrelation of horticultural characters, physical properties of the stalks and fibers, and fiber yield and recovery of different abaca cultivars, hybrids and *Musa* species.

Characters		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
Suckers/hill (no.)	(C_1)												
Harvestable stalks/hill (no.)	(C_2)	**											
Floating suckers/hill (no.)	(C_3)	**	ns										
Base stalk circumference (cm)	(C_4)	ns	ns	**									
Middle stalk circumference (cm)	(C_5)	ns	ns	**	**								
Top stalk circumference (cm)	(C_6)	*	*	**	**	**							
Stalk length (m)	(C_7)	ns	ns	*	**	**	**						
Stalk weight (kg)	(C_8)	ns	ns	**	**	**	**	**					
Leaf sheaths/stalk (no.)	(C_9)	ns	ns	*	**	**	**	**	**				
Fiber yield/stalk (g)	(C_{10})	*	**	ns	*	*	ns	**	*	**			
Fiber recovery (%)	(C_{11})	ns	ns	ns	ns	ns	ns	ns	ns	ns	**		
Tensile strength (km)	(C_{12})	ns	ns	ns	**	*	*	ns	*	**	ns	**	

** = significant at 1% level
* = significant at 5% level
ns = not significant

fibers can be extracted. Similarly, longer stalks generally have longer leaf sheaths from which longer tuxies can be extracted. Thus, longer fibers can be recovered resulting in higher fiber yield. Batugal and Tabora (1978) also noted that fiber bundles or strands are distributed predominantly in the tuxy region and extend from the basal portion of the leaf sheaths to the petiolar junction of the leaf blade. Results of the present study indicate that weight, length, basal and middle circumference of stalks, number of leaf sheaths as well as the number of suckers and harvestable stalks must be considered in selecting cultivars for high yield.

Fiber Yield

Fiber yield per stalk varied among the different clones (Table 3). 'Del Monte Puti' had the highest fiber yield per stalk (406.20 g) while 'Puti' had the lowest (36.32 g). 'Inosa', 'Lagurhuan', 'Baunan' and 'Minenonga' abaca cultivars produced more than 300 g of fiber per stalk. The small stalks of 'Puti', 'GAES No. 1', 'Sinalampago', 'Amokid' and 'Libutan' abaca cultivars and the medium-large stalks of 'Pacol x CES No. 3' hybrid as well as 'Canton' of the *Musa* species produced less than 100 g of fibers per stalk.

Fiber yield depends on the number of harvestable stalks and the physical characters of the stalks at harvest. The significant correlation between stalk weight and fiber yield could be attributed to the length, the basal and middle circumference of stalks as well as the number of leaf sheaths (Table 4). Generally, this implies that cultivars with heavier, longer and bigger stalks with more leaf sheaths are expected to give higher fiber yield. As Garcia (1959) reported, length and weight of stalks are positively associated with fiber yield.

Fiber Recovery

The higher percentage of fiber recovery in the abaca cultivars and the hybrid 'Lawaan x Tangongon' than in 'Pacol x CES No. 3' and the two *Musa* species could be attributed to the higher tensile strength of the fibers (Table 5). Strong fibers can withstand the pressure exerted by the blade of the stripping machine hence, more fibers can be recovered. On the other hand, tuxies extracted from clones with weak fibers tend to break easily and are wasted during stripping. This corroborates the findings of Bernardo (1957) that the low fiber recovery of 'Pacol x abaca F_1' hybrid and 'Canton' was due to the inherent weak fibers of these clones.

Tensile Strength of Fibers

The tensile strength of fibers obtained from different groups of leaf sheaths of the abaca clones and related *Musa* species is presented in Table 5. The fibers of 'Ogarum' were the strongest with mean tensile strength of 48.80 km while the fibers of 'Pacol x CES No. 3' had the

Table 5. Fiber recovery and tensile strength of fibers from different groups of leaf sheaths of some abaca cultivars, hybrids and *Musa* species. (Means of three harvests)

Clone	Fiber Recovery (%)	Tensile Strength (km)			
		Outer	Middle	Inner	Mean
Abaca Cultivars					
Ogarum	1.06	50.82	52.80	42.79	48.80
Sairaya	1.03	48.68	49.45	45.74	47.95
GAES No. 1	1.06	45.05	50.23	48.74	47.78
Sinalampago	1.15	44.41	46.52	49.56	46.83
Del Monte Pula	1.35	38.52	49.71	50.36	46.20
Baguisanon Puti	0.96	46.53	49.52	42.36	46.14
Samina	1.07	42.15	50.94	45.05	46.06
Ginabaki	0.93	44.68	47.01	46.01	45.90
Samorong Pula	0.92	43.86	46.21	46.51	45.53
Puti	1.12	46.92	47.38	40.84	45.05
Binagakay	1.29	48.11	40.12	46.22	44.95
Tinawagan Puti	0.97	45.59	49.72	39.31	44.87
Tangongon	0.98	40.55	47.72	45.48	44.58
Casilihon	0.75	45.53	47.32	40.60	44.49
Layahon	1.03	46.23	48.47	36.87	43.86
Lunhan	1.10	35.26	47.63	47.81	43.57
Binongongoran	1.14	41.42	50.56	38.52	43.50
Libutan	0.92	39.62	45.15	45.27	43.35
CES No. 3	0.93	47.36	48.53	33.95	43.28
Sugmad Pula	1.29	47.58	46.20	35.17	42.98
Del Monte Puti	1.14	41.90	43.55	43.43	42.96
Inosa	1.44	43.35	43.60	39.42	42.12
Canarahon	1.12	42.37	42.02	37.94	41.78
Bagakayon Kidit	0.85	43.76	44.72	35.86	41.45
Minenonga	1.34	43.22	44.61	34.87	40.90
Linawaan	1.48	44.12	32.01	46.29	40.84
Samoro	1.00	42.72	35.30	43.80	40.61
Baunan	1.66	42.29	44.10	34.17	40.19
Lagurhuan	1.23	41.97	48.38	38.70	38.70
Amokid	0.61	40.36	41.95	33.10	38.47
Bulao Luno	0.92	39.90	37.47	36.38	37.88
Inagutay	0.54	37.43	36.76	32.35	35.51
Hybrids					
Lawaan x Tangongon	1.26	44.59	45.96	43.29	44.61
Pacol x CES No. 3	0.35	26.65	31.30	23.03	26.99
Musa Species					
Tetraploid III	0.24	26.26	38.90	34.98	33.38
Canton	0.31	30.32	36.05	27.79	31.39
Mean	1.01	42.22	44.69	40.15	42.35
C.V. (%)	17.88	19.00			
	HSD .05 = 0.31			Clone HSD .05 = 7.36	
	.01 = 0.36			.01 = 8.31	
				Group HSD .05 = 4.26	
				.01 = 4.80	

lowest mean tensile strength of 26.99 km. The two related *Musa* species ('Tetraploid III' and 'Canton') had weaker fibers in all groups of leaf sheaths than the fibers from the abaca cultivars and the hybrid 'Lawaan x Tangongon'.

The inner group of leaf sheaths had weaker fibers than the outer and middle groups in most of the clones. The middle group of leaf sheaths generally had the strongest fibers.

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