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Morphological Characteristics of Abaca *(Musa textilis* Née) Cultivars Grown in Two Municipalities of Aklan, Philippines

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Abstract The present study identified the different abaca (*Musa textilis Nee)* cultivars grown in the 34 identified abaca producing barangays of Madalag and Libacao, Aklan, Philippines, and evaluated the morphological characteristics of the matured abaca plant such as plant height, number of suckers, number of leaves, the circumference of pseudostem and length of stalks. Stratified random sampling was conducted. From the two municipalities, there were 34 abaca-producing barangays identified, and three abaca plantations were randomly selected to obtain the morphological characteristics of the different abaca cultivars using the prescribed measurement procedures. Distribution of the cultivars determined through geospatial mapping using Geographic Information System (GIS). Statistical analyses employed were single factor analysis of variance (ANOVA) and T-test to determine significant differences among groups/cultivars at $\alpha = 0.05$ level of significance. The findings showed that there were four identified abaca cultivars commonly grown in Madalag and Libacao. These were *Bisaya, Tabukanon, Agbayanon* and *Negro* cultivars. Moreover, the morphological performance of the different cultivars responded differently. The study will provide relevant data on the distribution and morphological characteristics of abaca cultivars in the province. It could enhance programs and interventions in achieving the local and global demand for high-quality abaca fiber.

Keywords Distribution, Fiber, Geographic Information System, *Musae*, Variety

1. Introduction

The province of Aklan produced 82% of abaca in Western Visayas, Philippines in 2016, and the province also produces good quality fiber. In the country, the province of Aklan ranked 9th among the top 10 abaca fiber-producing provinces in 2016, producing 2,400 metric tons [1]. The Akeanon-Bukidnon indigenous peoples of Aklan have long relied on the harvest and trade of abaca fibers from the abaca plant as a major source of income [2]. However, some of these farmers don't recognize the cultivars they commonly used as planting material and rely solely on the physical attributes in varietal selection. Hence, there were no existing literature, techno guide, botanical descriptors and morphological characteristics of the abaca varieties used in the province of Aklan. Morphological characteristics are extremely important in the literacy world. Plant variety and cultivar identification are one of the most important aspects of agricultural systems. There was limited information on the morphological characteristics of the abaca varieties being used in the province of Aklan.

In the Philippines; several abaca varieties, their relatives and many hybrids exist. No less than 200 abaca varieties throughout the archipelago [3]. Several researches have shown that Musa cultivars vary in their gross morphological characteristics [4] – [6]. There are more than 700 accessions of abaca being maintained in ex-situ gene banks in the country [7] not including those abacas that can be found in the wild. Moreover, abaca is highly location-specific; i.e. a variety may be suitable in one location but not in another. Since the early years of cultivation, there are select outstanding varieties distinct in Luzon, Visayas and Mindanao. These varieties have shown adaptability and stability in their respective location, thus grown and stripped for the prized fiber. Despite the long history of abaca cultivation in the Philippines, no attempt has been made to register the varieties that have long been recommended [8]. Based on the PhilFIDA Aklan, the abaca varieties in the province are not yet registered with National Seed Industry Council (NSIC).

Studies on this aspect may be significant in the varietal screening, classification, and fiber yield. Further, the plant character in terms of its plant height, number of suckers, number of leaves, the circumference of pseudostem, length of stalks, and distribution of the different abaca cultivars produced in the Province of Aklan is not yet fully understood and explored. This study aimed to identify abaca cultivars, determine the geographical distribution, describe the morphological characteristics and significant differences among abaca cultivars in terms of plant height, number of suckers, number of leaves, the circumference of pseudostem, and length of stalks in the top 2 abaca-producing municipalities in the province of Aklan. The study will provide relevant data and information to the concerned Government Agencies and researchers on the geographical distribution and morphological characteristics of abaca cultivars in the province. It could enhance programs and interventions of these GAs for the benefit of farmers, producers, and stakeholders in achieving and meeting the local and global demand for high-quality abaca fiber.

2. Materials and Methods

Preliminary Survey. The preliminary information regarding abaca production was obtained from various agencies such as the Department of Agriculture, Philippine Fiber Industry Development Authority, Office of the Provincial Agriculture (OPA), and Local Government Units (LGUs). Information on the area planted per municipality, the number of farmers that are actively involved in abaca farming, cultivars planted, and the among others were secured from these agencies cited.

Respondents of the Study. The respondents in the study are abaca farmers reflected in the official list of the PhilFIDA and the concerned barangays. To be included in the list, they must have an existing abaca plantation of at least a quarter of a hectare. Ten (10) abaca farmers were randomly selected and identified by the researcher and assisted by the representatives from the Barangay Council of each barangay surveyed.

Study Sites Identification and Validation. Table 1 shows the full list of the abaca-producing barangays in the municipalities of Madalag and Libacao, Aklan, Philippines.

Table 1. Full list of the abaca-producing barangays in the municipalities of Madalag and Libacao, Aklan, Philippines.

Municipality of Madalag	Municipality of Libacao
Alas as	Manika
San Jose	Janlud
Dit-Ana	Guadalupe
Talangban	Calamcan
Panipiason	Bonza
Medina	Oyang
Paningayan	Rosal
Napnot	Sibalew
Pang-itan	Ogsip
Mercedes	Ortega
Mamba	Casit-an
Ma. Cristina	Pinonoy
Galicia	Loctuga
	Agamilig
	Alfonso XII
	Bato bato
	Julita
	Pampango
	Can-awan
	Dalagsaan
	Rivera

Source: PhilFIDA Aklan, 2017

Data Gathering

Survey questionnaire. Pre-tested validated and approved questionnaires were administered to the abaca farmers. Respondents were required to answer all of the questions based on their existing knowledge and experience. The researcher assisted the respondents, and all respondents affixed their signature or thumb mark after they have answered the questionnaires.

Field survey and data collection. The data on morphological characteristics were obtained from the fifteen randomly selected matured abaca plants per abaca plantation showing its flag leaf or a total of 45 sample plants per cultivar in three sampling sites of the 34 barangays.

Morphological Characteristic. Morphological characteristics of abaca cultivars were evaluated through validation and comparison of botanical descriptors of

abaca. Data on the different abaca cultivars regarding their height, number of suckers, number of leaves, the pseudostem circumference, and length of the stalk were collected on-site using the prescribed measurement procedures. Forty-Five (45) matured abaca cultivar that exists in the barangay showing its flag leaf was subjected for analysis to obtain the morphological characteristics of abaca per cultivar to differentiate the growth performance, in terms of:

a) **Height of the plant (cm).** Plant height was measured in cm from the base up to the highest leaf of the plant with the use of a meter roll.
b) **Number of suckers**. The number of suckers of the abaca plant emerging from the mother corm and soil surface at any size was determined through ocular observation and manual counting.
c) **Number of functional leaves/leaf sheath.** The functional leaves existing on the abaca plant were determined by counting the fully developed leaves.
d) **Circumference of the pseudostem (cm).** The circumference of the pseudostem was measured in cm one foot from the base of the plant using a tape measure.
e) **Length of the stalk (cm).** The length of the stalk was measured in cm with the use of a meter roll from the base of the abaca plant up to the first petiole — each stalk ranges from 12 to 20 feet in height.

Abaca cultivars and local name identification. The identification of abaca cultivars planted by the farmers was determined through their general appearance and characteristics such as plant height, pseudostem, and size of its fruits. Likewise, further evaluation through validation and comparison of the identified cultivar using reliable references such as abaca descriptors provided by the PhilFIDA. A key informant interview with the abaca farmers regarding the different cultivars planted and used was also conducted by the researcher for easy identification and further reference.

Data Management, Processing and Analysis. The identified abaca cultivars were recorded and tabulated for analysis. Geo-tagged photos were copied into GIS format to produce a map showing the exact location. Other references such as books, journals, and other similar information sources, were used in the abaca cultivar identification. Processing the geographic location of abaca cultivars was determined using the following procedures and applications:

Geomapping and lay-outing. An assessment of a geotagged photo was conducted through image quality control. Geotagged photos of cultivars were used in determining the geographic location. The geotagged photos taken were embedded with a date stamp, location coordinate, and altitude which can easily be uploaded to Google Earth in determining its exact geographic location. The geotagged photos were uploaded to Google Earth Software through the use of a Picasa photo viewer. The ARC GIS was used after the parameters were gathered and uploaded to Google Earth. Further, it was processed to the ARC GIS software, which came up with a layout of the geographic locations of each cultivar with corresponding legends and location map.

Data analysis. The data gathered were encoded and analyzed using qualitative and quantitative statistics. From the completed survey questionnaire, the data were encoded/tabulated and analyzed using Microsoft Excel. Descriptive statistical tools such as percentage, mean, and rank were employed in analyzing the data. The morphological characteristics of abaca varieties for each municipality were analyzed using single factor Analysis of Variance (ANOVA) to determine significant differences among groups/cultivars. Significant results were further analyzed using the Bonferroni Correction Test to determine significant differences between groups at a 95 % confidence level (alpha = 0.05).

3. Results and Discussions

The Commonly-Grown Abaca Cultivars in the Two Municipalities. Figure 1 shows, the four abaca cultivars were being planted by the farmers, three of which are commonly planted by both farmers of Madalag and Libacao. These are the , *Tabukanon*, *Bisaya*, and *Agbayanon*. Only farmers of Libacao planted the *Negro* cultivar. These cultivars are commonly planted in these areas because it is relatively easy to propagate and readily available in the area. These cultivars were also known to be indigenous in the Province of Aklan. It was shown in Figure 2, that among all the cultivars, *Bisaya* is the most frequently used planting material by the farmers in Madalag and Libacao having 92.30% and 95.24% respectively of the identified abaca producing barangays. The farmers preferred to use the *Bisaya* cultivar for abaca production primarily because it has good yield attributes due to its suckering ability as it affirmed in the morphological performance of the study, thus, higher economic returns to the farmers. Likewise, it is more convenient to harvest the *Bisaya* cultivar because of its height and lightweight features that are easy to haul from the plantation site up to the access road.

Tabukanon Bisaya Agbayanon Negro

Figure 1. Four abaca cultivars identified and grown by the abaca farmers in the municipalities of Madalag and Libacao, Philippines

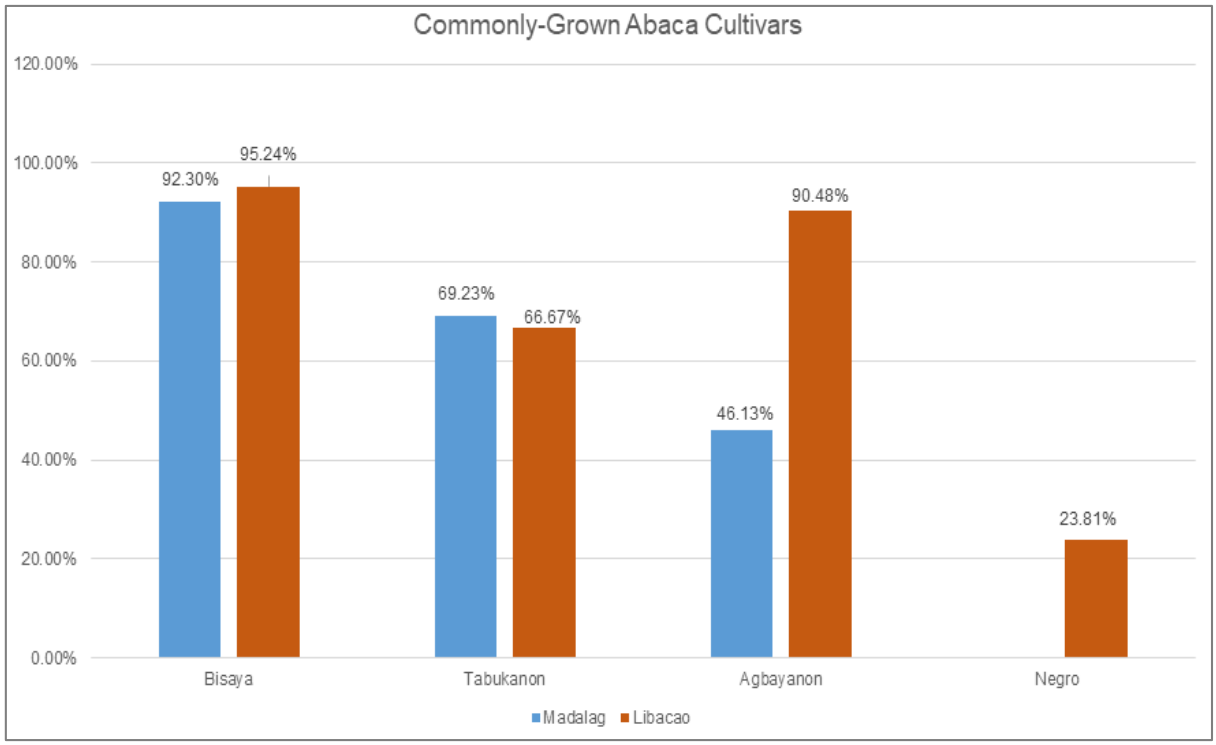

Figure 2. Commonly-grown abaca culitvars in the municipalities of Madalag and Libacao, Philippines

Moreover, the least cultivar grown by the abaca farmers is the *Agbayanon* cultivar in Madalag with 46.13% and *Negro* cultivar in Libacao with only 23.81% Notably, this Negro cultivar is only grown in Libacao and showed ideal morphological performance among all the cultivars identified. However, it only produces 1 to 2 suckers, which is one of the primary considerations of the farmers for production. In addition, it requires more space because of the wider planting distance due to its height and a larger canopy. Figures 3 and 4 presented the geographical distribution of the different abaca cultivars planted in the Municipality of Madalag and Libacao, Aklan.

Musae is vegetatively propagated from suckers developing from the main plant. Sucker development consists of three distinct stages: peer (small sucker appearing just above the ground and bearing scale leaves only), sword sucker (large sucker with lanceolate type leaves), and maiden suckers (large sucker with foliage leaves) [9]. A sucker is a lateral shoot that develops from the rhizome and usually emerges close to the parent plant.

Farmers traditionally depend on this natural regeneration process to replace their mother plants. Suckers can also be extracted from the mat for transplanting, sharing with farmers, or selling, a practice that contributes to the spread of pests and diseases [10]. Cultivars with good suckering ability produce higher fiber yields that can be extracted from their stalk. Hence, dried fibers could also weigh much heavier. In this case, the farmers will gain more profit because the trade of abaca fiber in the market is on a per weight basis.

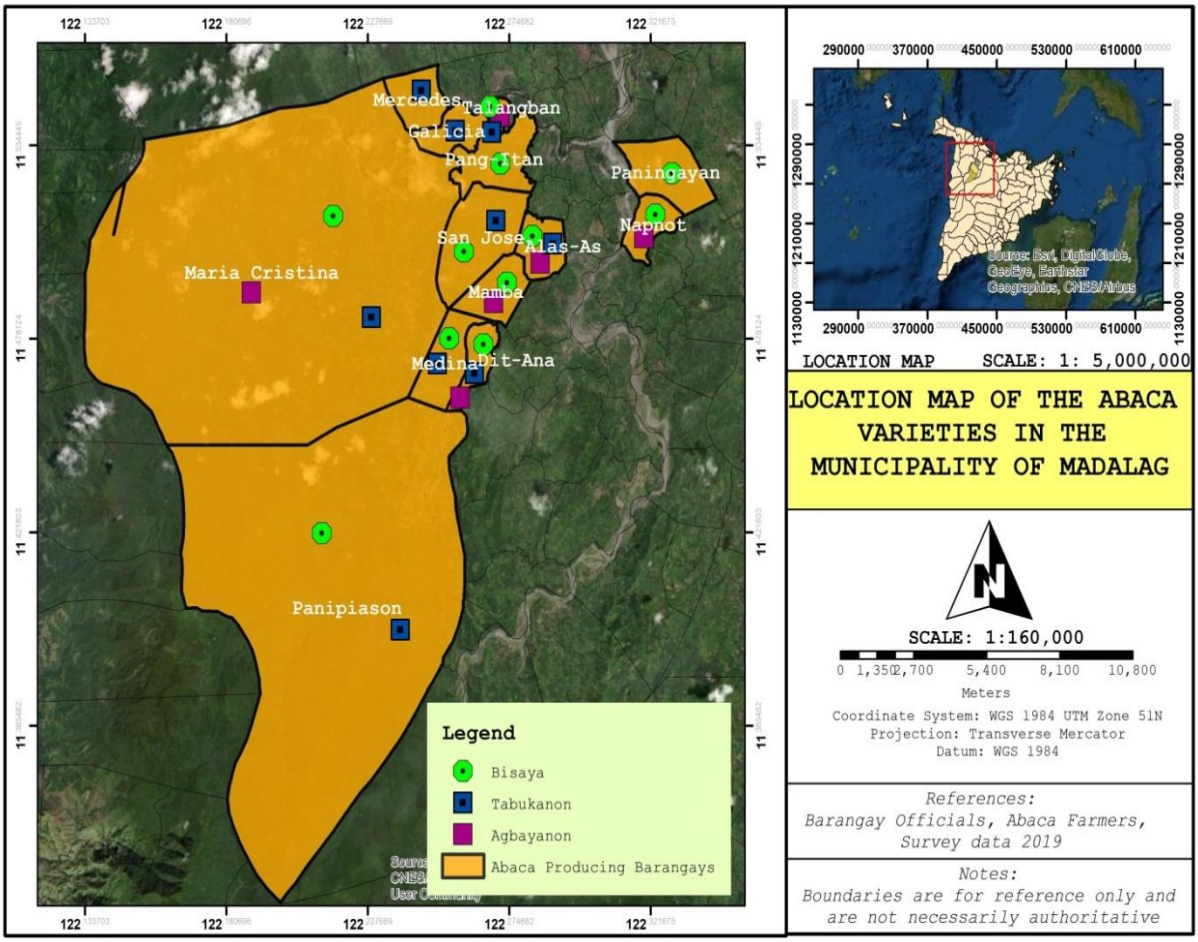

Figure 3. Location map of the abaca cultivars grown by the farmers in the Municipality of Madalag, Aklan, Philippines.

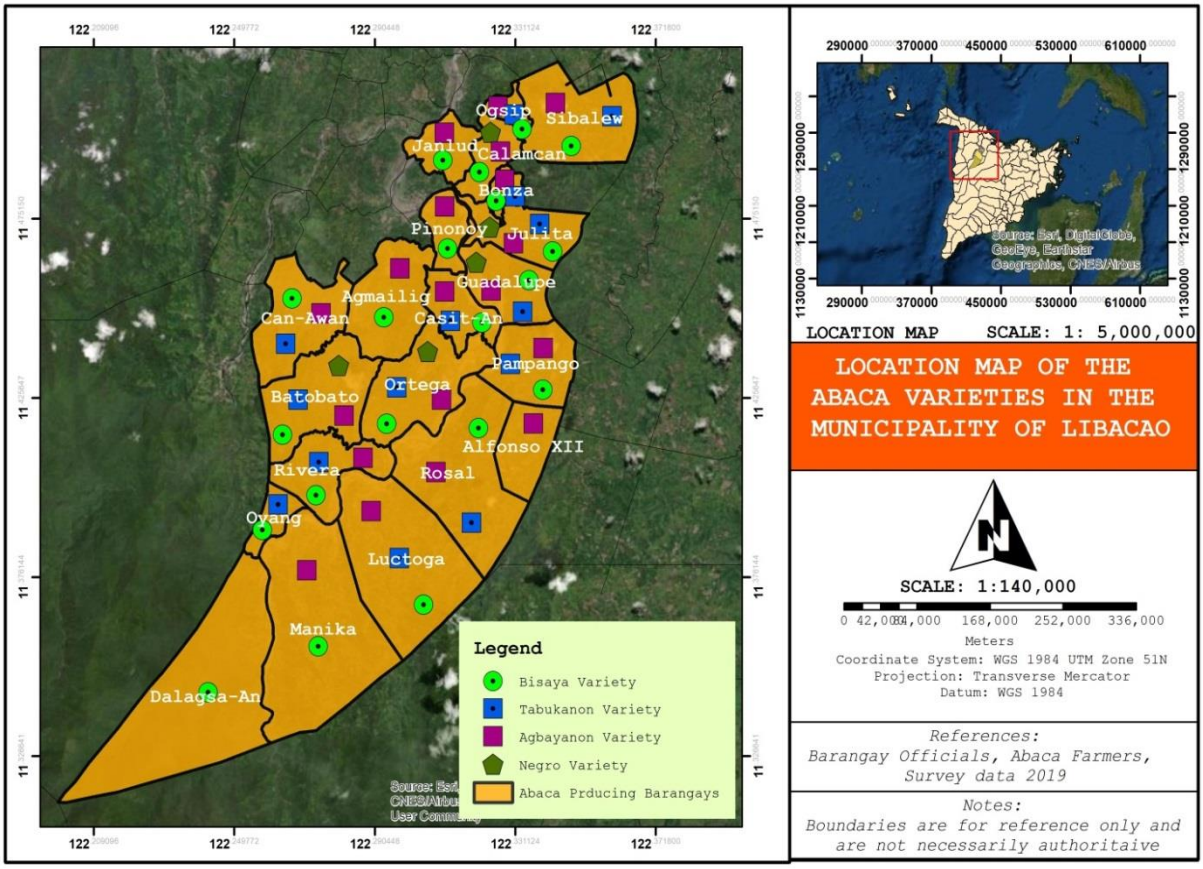

Figure 4. Location map of the abaca cultivars grown by the farmers in the Municipality of Libacao, Aklan, Philippines.

Table 1. Morphological characteristics of different abaca cultivar planted in the municipalities of Madalag and Libacao, Aklan, Philippines.

Morphological Characteristics	CULTIVAR			
	Bisaya	Tabukanon	Agbayanon	Negro
Municipality of Madalag				
Plant Height(cm)	408.75^{a}	364.67^{b}	417.67^{a}	
Number of Suckers	5.58^{a}	5.33^{a}	4.33^{a}	
Number of Leaves	7.58^{a}	7.00^{a}	7.00^{a}	
Circumference of Pseudo stem (cm)	34.28^{b}	31.00^{b}	44.28^{a}	
Length of Stalk (cm)	299.20^{a}	264.70^{a}	345.67^{a}	
Municipality of Libacao				
Plant Height(cm)	397.93^{c}	325.36^{b}	492.36^{a}	556.60^{a}
Number of Suckers	4.89^{ab}	6.20^{a}	4.26^{b}	1.40^{c}
Number of Leaves	7.80^{a}	7.71^{a}	8.05^{a}	9.20^{a}
Circumference of Pseudo stem (cm)	35.02^{b}	24.96^{c}	40.97^{a}	45.00^{a}
Length of Stalk (cm)	267.35^{c}	256.15^{c}	399.47^{b}	469.20^{a}

Note: Different superscript letter indicate statistical significance (Hans-Peter Piepho).

Morphological Characteristics of the Different Abaca Cultivar Grown in the Municipalities of Madalag and Libacao, Aklan, Philippines. As reflected in Table 1, the growth performance of the various cultivars responded differently in Madalag and Libacao. The majority of the morphological characteristics of the Bisaya and Tabukanon cultivars show no significant differences. The study implied that the growth performance of the different abaca cultivars in the two municipalities is location-specific. The performance of the abaca cultivar depends on where it is located and planted based on the locations, pedological characteristics, elevations,

topography, and vegetative cover. Based on the results, it may be noted that each cultivar identified in the municipalities of Madalag and Libacao shows different morphological characteristics than the other cultivars being used by the farmers in other abaca-producing provinces. Moreover, the morphological performance of the different cultivars responded differently.

According to the study conducted by the PhilFIDA in 2000, on the adaptability of selected abaca varieties under different agroclimatic conditions in the Philippines, the interaction effect of the location of the abaca varieties on fiber yield was significant. Similarly, abaca varieties responded differently to the location specified in Bicol, Leyte, and Maguindanao [11].

Plant Height. The data indicated that the plant height of *Bisaya* (408.75 cm) and *Agbayanon* (417.67 cm) in the municipality of Madalag was not significantly different from each other. However, *Tabukanon* (364.67 cm) is significantly shorter than the two abaca cultivars. Further, the data revealed that the *Negro* (556.60 cm) and *Agbayanon* (492.86 cm) cultivar in Libacao has no significant difference in terms of height. On the contrary, these two cultivars have significant differences from other cultivars such as *Bisaya* and *Tabukanon*. Moreover, the data revealed that the *Negro* cultivar is best in terms of plant height among all the cultivars grown. While the shortest was observed in the *Tabukanon* cultivar.

Based on its botanical descriptor, the abaca plant grows to 13-22 feet (4.0-6.7m) an average of about 12 feet (3.7m) [12]**.** The *Inosa* variety used in Eastern Visayas is much similar to *Bisaya* and *Tabukanon* in terms of plant height (3.0 - 4.0 m tall), additionally, it has upright leaves with tips tending to curl upward same with *Bisaya* and *Tabukanon*. The *Agbayanon* in Madalag has grown about a mean height of 4.17 m whereas Negro in Libacao grows about 5.5 meters tall. In some variety particularly in Mindanao, the *Tangonon* variety is much similar to the plant height of the *Negro* and *Agbayanon* cultivar ranging from 4.5 - 5.5 m tall (Gonzal and Valida, 2016). The data seem to indicate that *Agbayanon* and *Negro* cultivar are thriving best having the highest mean in terms of height in the municipalities of Madalag and Libacao.

Abaca requires a warm and humid climate for optimum growth and productivity. Based on the abaca sustainability manual of the PhilFIDA in 2016, the abaca requires about 40 - 50% shade [14] and the municipalities of Madalag and Libacao have huge vegetative cover such as an open and closed forest. In addition, the majority of the abaca plantations were planted under leguminous trees such as rain trees and *maganhop* trees. These factors may have influenced the performance of abaca and other factors such as optimum light, nutrient, and water requirements of abaca. Leguminous trees are highly recommended because they do not only provide shade but also enrich the soil with nitrogen through a symbiotic relationship with soil bacteria [15] Other agricultural practices by the farmers may have also contributed a significant effect on the performance of the different abaca cultivars planted in these two municipalities.

Number of Suckers. As indicated in the figure, there was no significant difference in the number of suckers of the different cultivars grown in Madalag. However, the mean suckers per clump for *Bisaya*, *Tabukanon* and *Agbayanon* has a mean of 5.58, 5.33 and 4.33 respectively. Furthermore, the data showed that the *Bisaya* cultivar grown in Libacao was not significantly different compared to Agbayanon and Tabukanon. On the other hand, *Agbayanon*, *Tabukanon*, and *Bisaya* cultivars have a significant difference from the *Negro* cultivar. Moreover, the data also show that *Tabukanon* produces more suckers in Libacao having a mean of 6.20 suckers/clump. Whereas, the *Negro* was outnumbered, indicating poor performance in terms of suckering ability producing a mean of only 1.40 sucker/clump.

The number of suckers is one of the primary reasons why farmers in Madalag and Libacao are commonly using the *Bisaya* and *Tabukanon* cultivar as their planting materials for the production of abaca. The good suckering ability of these cultivars contributed to higher yields compared to other cultivars grown in the locality. Some farmers do not usually plant the *Negro* cultivar because it produces fewer suckers and requires more planting space because of its phenotypic characteristics in terms of height and canopy structure.

Notably,the *Bisaya* and *Tabukanon* cultivars are much similar to the *Inosa* variety which is a commercially grown variety in Eastern Visayas. Relatively, the *Inosa* is also resistant to drought and has a good suckering ability producing about 5 - 7 suckers/clumps [13] which is similar to *Bisaya* and *Tabukanon* cultivar that is commonly grown in Madalag and Libacao areas. Meanwhile, the *Negro* cultivar is much similar to the *Tangongon* variety which is commonly grown in Mindanao producing about 1 - 2 suckers/clumps [13] and quite similar with the abaca clones “Canton” and “Bulao Luno” which obtains the lowest number of suckers producing an average of 1.37 suckers per hill [16]. In this case, the height of the abaca plant may have a significant effect on the number of suckers produced by the cultivar.

Furthermore, the *Bisaya* and *Tabukanon* are considerable cultivars to the farmers of Madalag and Libacao as it gives good yielding attributes and has excellent suckering ability indicating the highest mean in the number of suckers. Likewise, the greater number of harvestable stalks produced by profusely suckering cultivars indicates a strong relationship between the production of harvestable stalks and stooling ability of a variety. This observation 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 is important in replenishing harvested stalks and thus, a desirable character of abaca [16].

Number of Leaves. The data revealed that there were no significant differences among all the cultivars grown in

Madalag. However, data show that the *Bisaya* cultivar obtained a mean of 7.58 leaves/plant whereas *Agbayanon* and *Tabukanon* tied with exactly 7.00 leaves/plant. Similarly, the data also revealed that the number of leaves of the different abaca cultivars in Libacao has no significant difference from each other. However, the number of leaves/plant for Negro, Agbayon, Bisaya and Tubkanon has a mean of 9.20, 8.05, 7.80 and 7.71 respectively in Libacao.

The number of leaves indicates the total number of leaf sheaths within the stalk of the abaca plant where the abaca fibers are extracted from. Based on its botanical description, the abaca plant produces around 12 - 25 leaves [17] which is more than the number of leaves obtained in Madalag and Libacao. Primarily, these cultivars are native or indigenous to the province which basically can only be found in Aklan and associated with different growth factors such as climate, soil type, and cultural management practices. Hence, the data show that all the cultivar grown in Madalag and Libacao has no significant differences in terms of the number of leaves. Reference [18] shows on the nutrient composition of abaca (Musa textilis Nee) at seedling, vegetative, and flag leaf stages of growth for the determination of macro and micronutrients present in the abaca through destructive sampling, he found out that the elements present in the leaves for the seedling, vegetative and flag leaf stage are the N, P, Ca, Mg and Mn. It may be assumed that these nutrients are maybe lacking or insufficient in Madalag and Libacao to support its growth performance in terms of the number of leaves.

Circumference of the Pseudostem. The data revealed that the *Agbayanon* has a significant difference in the circumference of the pseudostem when compared to *Tabukanon* and *Bisaya*. Whereas, there was no significant difference between the *Bisaya* and *Tabukanon* cultivars. Further, the data also revealed that there was no significant difference in the circumference of the pseudostem between *Negro* and *Agbayanon* cultivar in Libacao. However, these two cultivars have a significant difference between the *Tabukanon* and *Bisaya* cultivars.

Moreover, data show that the biggest mean circumference in Madalag was observed in the *Agbayanon* cultivar having a mean of 44.28 cm while the least was observed on *Tabukanon* cultivar having a mean of only 31.00 cm. The data also shows that the biggest mean circumference in Libacao was obtained from the Negro cultivar showing a mean of 45.00 cm. Whereas, the least data recorded was observed on the *Tabukanon* having a mean of only 24.96 cm. Further, data shows that the biggest mean circumference in Libacao was obtained from the *Negro* cultivar whereas, the least data recorded was observed on the *Tabukanon* in both municipalities.

The pseudostem continues to grow in height as the leaves emerge one after the other and reach its maximum height when the inflorescence emerges at the top of the plant [10]. Therefore, the data indicate that plant height is one factor that has influenced the circumference of the pseudostem of the abaca cultivars. Consequently, the taller the abaca plant, the larger in size of the circumference of the pseudostem as the data shown for Agbayanon and Negro.

Length of the Stalk. Data showed that the *Agbayanon*, *Bisaya*, and *Tabukanon* cultivar grown in Madalag shows no significant difference in terms of length of stalk. However, the data indicate that the mean length obtained from *Agbayanon* has a mean of 345.67 cm whereas *Bisaya* has 299.20 cm and *Tabukanon* has 264.70 cm in length. Further, the data also revealed for the cultivars in Libacao shows that between *Bisaya* and *Tabukanon* there was no significant difference observed in terms of the length of the stalk between the two cultivars. However, these two cultivars have a significant difference between the *Agbayanon* and *Negro*. Moreover, the highest mean length of the stalk was recorded in *Negro* cultivar having a mean of 469.20 cm in length whereas the shortest was still obtained with the *Tabukanon* showing a mean of 256.15 cm in length.

Reference [19] shows that the *Magino* Hybrid, *Maguindana*o,and *Bongtang* variety show a significant effect in terms of the length of the stalk (4 meters in length), which is similar to the length of the stalk of *Negro* and *Agbayanon* with an average length of 4 meters. By analyzing the numerical figures, data for the length of the stalk has a similarity to the data for the height of the abaca cultivar. The taller the abaca cultivar the longer the abaca stalk. Further, the size of the stalks could determine by the number of sheaths. The bigger the stalk with more leaf sheath produces heavier stalks hence, more fibers can be extracted. Similarly, longer stalks generally have longer leaf sheaths from which tuxies can be extracted. Thus longer fibers can be recovered resulting in higher fiber yield [16]. Reference [18] shows that the nutrient composition of the fiber of the stalks, the dominant elements present are iron and potassium, which may also be present on the soil of the Municipalities of Madalag and Libacao as required by *Negro and Agbayanon.*

4. Conclusions

The study revealed that four abaca cultivars are being planted by the farmers, three of which are commonly planted by both farmers in Madalag and Libacao. These are the Bisaya, Tabukanon, and Agbayanon. Some farmers of Libacao planted the Negro cultivar. Based on the data gathered, the Bisaya cultivar is the most frequently and widely used cultivar by the farmers in both municipalities primarily because this cultivar has good yielding attributes such as suckering ability. The study also revealed that the morphological performance of the different cultivars responded differently in both municipalities. It was also found that the majority of the morphological characteristics of Bisaya and Tabukanon show a not significant difference

between the two cultivars. The different abaca cultivars showed wide variation in all morphological characteristics evaluated. Results of the present study indicate that plant height, number of leaves, number of suckers, and length of the stalks must be considered in selecting cultivars for high yield.

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