Research article

Agroecological Assessment of Different Cultural Practices of Pineapple, *Ananas comosus*, (Linn) Mer. (Var. Red Spanish) for Sustainable Fiber Production in Geo-Textile Industry in Balete, Aklan

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Abstract Pineapple fiber offers a promising contribution in the developing geo-textile industry in Balete, Aklan. To support this initiative, a study was conducted to assess the different agroecological production systems of *Ananas comosus* var. Red Spanish for fiber production and determine the biomass production, fiber yield, and fiber recovery of Red Spanish grown under different agroecological production systems. Five study sites were selected with varying socio-cultural management systems which included a) intensive pineapple monoculture; b) traditional pineapple monoculture; c) pineapple-rambutan-gmelina; d) pineapple-rambutan-banana and e) pineapple-indigenous trees. Results showed that the pineapple planted underneath the indigenous trees significantly ($p \leq 0.05$) produced lower biomass but higher fiber yield ($p \leq 0.05$) as compared to the other four production systems studied. It was found out that there was a significant correlation ($r=0.93$) between leaf weight, length, and fiber yield. However, no significant difference on fiber recovery was observed between study sites. On the other hand, pineapple-indigenous trees agroecological system had higher NPK contents compared to those in the other study sites. Therefore, integrating the pineapple with indigenous trees is the most sustainable production system since this will lead to better soil fertility and provide optimum fiber yield.

Keywords pineapple fiber, geo-textile industry, production systems, agroforestry

INTRODUCTION

The Red Spanish pineapple is highly recommended in the Philippines not just for its fruit but also for its fiber. The Red Spanish pineapple is an asexually propagated crop and is normally multiplied by using crown, sucker, and slip. It adopts to a wide range of soil and climatic conditions, although a well-drain soil which has a pH range of 4.5-5.5 was considered ideal. Most pineapple plantation, usually has an average planting density of 33, 333 plants/ha. The Red Spanish variety yields an average of 12-16 long leaves per plant. The leaves are usually harvested 18-24 months after planting to obtain the well-formed fibers. The first layer of fiber - is locally known as the "Bastos" (coarse) and the second layer – the "Liniuan" (fine) fiber. These are manually extracted from the leaves (FIDA, 2010). The inappropriate application of fertilizer, poor weed management, and irrigation are some of the factors that may affect the production of fiber (Tabora, 1977).

According to Montilona (1991), the Red Spanish should be grown in shaded or partially shaded area for it to produce long and pliable fibers. However, the Fiber Industry Development Authority (FIDA, 2010) reported that when the crop is grown in an open field it produces stronger fibers. The pineapple fiber has a good tensile strength which makes it a good material in making geo-textiles. This makes the pineapple fiber an important material in Aklan. The Aklanons believe that these fibers could be a great potential in the local and world market. This study was conducted in Balete Province of Aklan, Philippines to assess the different cultural management practices of the growers involved in cultivating the Red Spanish pineapple. The result of this study will provide valuable information and identify gaps to be used in improving sustainable production and supply of pineapple fiber for geo-textile industry in Balete, Aklan.

OBJECTIVES

This study was conducted to investigate and assess the different agroecological production systems of *Ananas comosus* for fiber production and determine the biomass production, fiber yield, and fiber recovery of *Ananas comosus* production systems on Balete, Aklan, Philippines.

METHODOLOGY

Research duration: This study was conducted from July to August 2016 in collaboration with the non-timber forest products (NTFP) task force Philippines.

Selection and description of study site: This study was conducted in Balete Province of Aklan, Philippines which was selected based on different cultural production practices of the growers involved in cultivating the Red Spanish pineapple. These were: a) intensive pineapple monoculture; b) traditional pineapple monoculture; c) pineapple-rambutan-gmelina; d) pineapple-rambutan-banana; e) pineapple-indigenous trees.

Collection of soil sample: The soil samples were collected on the selected sites. About 1,000 grams of composite soil samples from each site were collected for physico-chemical analysis at the Central Analytical Service Laboratory (CASL) of the Visayas State University (VSU). In identifying the soil, a soil profile characterization, and observation of the soil physical properties in the field were done.

Collection of tissue and fiber samples: The pineapple plant samples were collected randomly from the selected plantations. This was done two days before the termination of the study. There were 18 sample plants collected in each production site. These samples were placed in a sack and were brought back to VSU for further laboratory analysis. The fibers were extracted using the traditional stripper. Fibers were classified and weighed and fiber yield plant^{-1} was determined. Fiber recovery plant^{-1} (in relation to leaf fresh weight) was calculated using the formula:

$$F_{R\,(\text{leaf fresh weight})} = \frac{W_F}{W_P} \text{ x } 100 \qquad \text{Eq. 1}$$

Where: $F_{R\,(\textit{leaf fresh weight})}$ = Stripped fiber recovery per plant (%)
W_F = Total weight of dried fiber per plant (g)
W_P = Total weight of harvestable leaves per plant (g)

Determination of Dry Biomass: Ten sample pineapple plants from each plantation site were carefully selected ensuring that they were in optimum growth condition. Biomass samples were partitioned into plant organs. For each plant fraction, fresh and dry weight (after over drying at an appropriate temperature and time until a constant weight was reached) were determined. The tissue samples were weighed using digital analytical balance. Then the percent moisture content and percent dry biomass were computed using the formula as cited by Bande (2013), Lambers et al. (1998) and Lahav and Turner (1985):

$$\text{Moisture Content (\%)} = \frac{\text{fresh weight (g)} - \text{dry weight (g)}}{\text{fresh weight (g)}} \text{ x } 100 \qquad \text{Eq. 2}$$

$$\text{Dry weight} = \frac{\text{Fw}}{\text{Mc}} \qquad \text{Eq. 3}$$

Where: F_w = the mass of fresh matter in a tissue (g)
M_c = moisture content in a tissue

$$\text{Biomass}_{\text{Proportional Distributions}} = \frac{Mo}{Mw} x\ 100 \qquad \text{Eq. 4}$$

Where: M_o = the mass of dry matter in a tissue (g)
M_w = the mass of dry matter in the whole plant (g)

Statistical analysis: All data were tested for normality and homogeneity using PROC Univariate of Statistical Analysis System version 9.1 (SAS, 2003). PROC GLM (general linear model) procedure was initially performed to assess the significant effects of production system on pineapple's total biomass, fiber yield and fiber recovery. The final models for each response variables were analyzed but including only those significant main factors and interaction effects. Duncan multiple range test (DMRT) and least squares differences (LSD) were carried out to compare different production system means of independent variables with significant variations at probability<0.05.

RESULTS AND DISCUSSION

Agroecological Description of the Different Pineapple Production Systems

1. Intensive Pineapple Monoculture Production System

The study site is in Barangay Fulgencio, Balete, Aklan (11° 35′ 42.65″ N and 122° 22′ 25.21″ E) on an alluvial terrace with an elevation of 49 meters above mean sea level and a slope of 0-3%. The site has an average annual precipitation of 2,600 mm yr^{-1} and a mean annual temperature of 27.5°C. The site was previously planted with maize (*Zea maize*) and banana (*Musa* sp.) then left under fallow for five years. This production system was established in 2015 by the members of the Aklanon Piña Fiber Producer's Association (APFiPA) with high planting density associated with intensive application of commercial fertilizer and weeding to attain a maximum fiber yield.

The soil analysis revealed that the texture of the surface horizon on this production site was clay loam with 1.6% soil organic carbon which is suitable for pineapple production (Table 1). Ficciagroindia (2007) reported that pineapple can suitably be grown on sandy and loamy soils that is rich in humus. Otsuka, et al. (1988), and Asio (1996) reported organic C content of the A horizons of some volcanic soils in the Philippines ranged from 0.79 to 11.1%. Organic carbon in agricultural soils contributes positively to soil fertility, soil tilt, crop production and over-all soil sustainability (Bauer and Black, 1994; Lal, et al., 1997; Reaves, 1997). The soil chemical analysis results revealed that NPK contents in the soil was generally low for crop production. According to Hoffmann's (1991), the nutritional standard for phosphorus on agronomic crops, soils with values within the range between 0-22 mg kg^{-1} is classified as low (category A) for plant nutrition. On the other hand, soils having available potassium values of 67-141 mg kg^{-1} are moderate (category B) for plant nutrition (Hoffmann, 1991).

2. Traditional (less intensive) Pineapple Monoculture Production System

This production system is located in Barangay Guanko, Balete, Aklan (11° 29′ 58.20″ N and 122° 22′ 56.35″ E) about 15 km south of Balete town at an elevation of 156 masl. The site was selected since traditional way of growing Red Spanish pineapple for fiber production is still being practiced. The socio-cultural management was different from the first site since there was no application of inorganic fertilizer and less intensive weeding was observed. In this production system, available P and exchangeable K was considerably higher than the first study site. Based on the interview conducted with pineapple growers, regular burning of cogon grass (*Imperata cylindrica*) is practiced during land preparation prior to planting of pineapple suckers or crown. This was confirmed on the soil organic carbon analysis where a significant difference was observed between the SOC value in site 1. Meanwhile, the phosphorus and available potassium in this production system qualifies under category A (low) and E (very high); respectively, based on Hoffmann's

(1991) nutritional standard on agronomic crops.

3. Pineapple-Rambutan-Gmelina Production System

The site is in Barangay Guanko, Balete, Aklan (11º 28′ 38.17″N and 122º 22′ 41.84″ E) about 15.5 km south of Balete town at an elevation of 208 masl. It is presently planted with gmelina (*Gmelina arborea*) and rambutan (*Nephellium lapaceum*). As part of the production system, Red Spanish pineapples were intentionally planted underneath the existing trees and/or fruit trees which provides shade to the pineapple plants. According to the pineapple grower, he had been practicing the production system for 5 years already which provided considerable increase in his farm income. The soil nutrient analysis results showed that the total nitrogen was 2.4 g kg^{-1} while available phosphorus was 0.05 mg kg^{-1} and exchangeable potassium 107.50 mg kg^{-1}. This means that P and K content in the soil were generally low and moderate; respectively, for plant nutrition on agronomic crops (Hoffmann, 1991).

Table 1 Soil chemical characteristics of the different Red Spanish pineapple production systems

Study Site	Agroecological Production System	OC (%)	Total N (%)	Avail P (mg/kg)	Exch K (mg/kg)	pH (1:2.5)	Exch Al (mg/kg)
1	Intensive Pineapple Monoculture Production System	1.60	0.23	0.56	64.48	4.95	12.18
2	Traditional Pineapple Monoculture Production System	3.51	0.34	2.39	661.25	4.64	7.81
3	Pineapple-Rambutan-Gmelina Production System	2.81	0.24	0.05	107.50	4.87	17.74
4	Pineapple-Rambutan-Banana Production System	2.46	0.23	0.46	247.50	4.94	18.15
5	Pineapple-indigenous trees Production System	3.61	0.36	3.54	308.75	4.56	12.05

4. Pineapple-Rambutan-Banana Production System

This production system is in Barangay Guanko, Balete, Aklan (11º 27′ 27.07″N and 122º 22′ 17.0″ E) about 15.8 km south of Balete town at an elevation of 243amsl. It is presently planted with rambutan (*Nephellium lapaceum*) and banana (*Musa spp.*). As part of the multi-strata agroecological production system, Red Spanish pineapples were intentionally planted underneath the existing fruit tree and bananas which provide shade to the pineapple plants. The soil nutrient analysis results revealed that soil texture was clay loam and SOC was 2.46%. Like in study sites 1 and 3, both available P and exchangeable K in the soil were generally low for plant nutrition in agronomic crop (Hoffmann, 1991).

5. Pineapple-Indigenous Trees Production System

This production system is practiced in Barangay Guanko, Balete, Aklan (11º 26′ 48.73″N and 122º 22′ 17.15″ E) about 16 km south of Balete town at an elevation of 246 masl. The site was selected since it is different from the other production systems where the early succession native trees were intentionally allowed to regenerate which provides shade to the pineapple plants. Generally, this production system has a higher NPK contents compared to those in the other study sites.

Biomass Production and Proportional Allocation of Dry Biomass

Total dry matter accumulation differed significantly ($p \leq 0.05$) among harvested Red Spanish pineapple sample plants from different agroecological production systems. Results showed that those Red Spanish pineapple planted in the intensive monoculture system has significantly (p≤0.05) higher total biomass production than the other four production systems being studied (Figure 1). This was followed by plants harvested from the traditional monoculture system which has comparable dry matter accumulation with plants grown in the pineapple-rambutan-gmelina and pineapple-rambutan-banana production systems. The higher biomass production in the intensive monoculture was because of the exhaustive application of inorganic fertilizer compared to the other production systems.

Furthermore, farmers who are engaged in the production of Red Spanish pineapple are concerned on the quality and quantity of leaves produced per plant since the fibers are extracted from the leaf. Based on the results of the study, pineapple grown under the intensive monoculture production system significantly (p≤0.05) produced more leaves than those grown using the pineapple-indigenous trees but had comparable leaf production with plants grown in traditional monoculture, pineapple-rambutan-gmelina and pineapple-rambutan-banana production system.

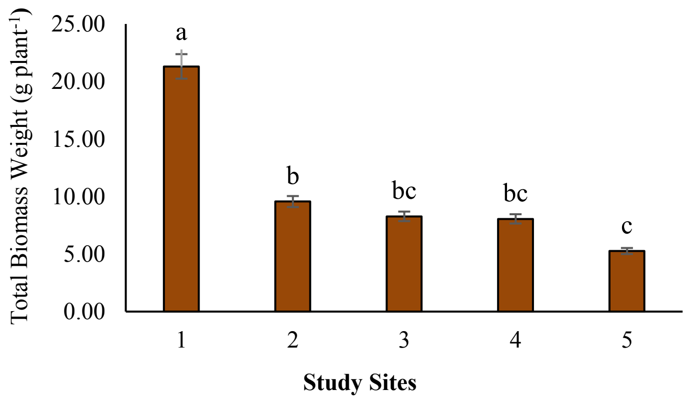

Fig. 1 Dry biomasss production (g plant^{-1}) of Red Spanish pineapple planted in different agroecological production systems

(*Note: LSD values with letter supersript (a-c) between study sites are significantly different (p ≤ 0.05); N = 14; **1** = Intensive Pineapple Monoculture, **2** = Traditional Pineapple Monoculture, **3** = Pineapple-Rambutan-Gmelina, **4** = Pineapple-Rambutan-Banana, **5** = Pineapple-Indigenous Trees*)

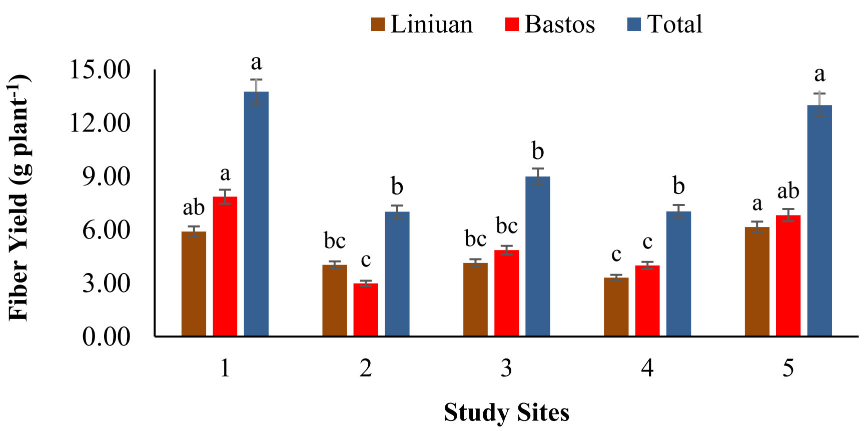

Fig. 2 Primary (bastos), secondary (liniuan) and total dry fiber yield (g plant^{-1}) of Red Spanish pineapple planted in different agroecological production systems

(*Note: LSD values with letter supersript (a-c) between study sites are significantly different (p ≤ 0.05); N = 14; **1** = Intensive Pineapple Monoculture, **2** = Traditional Pineapple Monoculture, **3** = Pineapple-Rambutan-Gmelina, **4** = Pineapple-Rambutan-Banana, **5** = Pineapple-Indigenous Trees*)

Fiber Yield and Fiber Recovery

According to FIDA (2010), the pineapple fiber is usually composed of coarse or primary "bastos" and fine or secondary "liniuan" fibers which are manually extracted from its leaves. The results of the study revealed (Fig. 2), there was a significant difference ($p \leq 0.05$) on total, primary (bastos) and secondary (liniuan) fibers yield between intensive pineapple monoculture and pineapple-indigenous trees production systems to traditional monoculture, pineapple-rambutan-gmelina, and pineapple-rambutan-banana production systems. Furthermore, FIDA (2010) reported that fiber yield depends on the number of harvestable leaves and the physical characters of the leaves at harvest. It was found out that there was a significant correlation between leaf weight, length, and fiber yield. This was consistent with the result in this study where there were highly significant correlations ($r=0.93$) between fiber yield and leaf weight.

On the other hand, the results on fiber recovery calculation showed no significant difference among different agroecological production systems (Table 2). However, the pineapple grown under indigenous trees has higher fiber recovery than the other four production systems. The data on fiber recovery also revealed lower secondary (Fine) fiber recovery than primary (Coarse) fiber. The low fiber recovery of the "Fine" fiber was probably due to the developed parenchyma cells attached to the fibers and to presence of stigmata. In contrast the rough surface of primary fiber resulted to easier extraction time and higher recovery during stripping.

Table 2 Recovery (%) of bastos (primary), liniuan (secondary) and total fiber extracted from the leaves of the Red Spanish pineapple in different agroecological production systems

Agroecological Production System	Fiber Recovery (%)		
	Fine	Coarse	Total
Intensive Pineapple Monoculture	0.42 ± 0.11^a	0.55 ± 0.14^a	0.97 ± 0.22^a
Traditional Pineapple Monoculture	0.48 ± 0.11^a	0.32 ± 0.14^a	0.80 ± 0.22^a
Pineapple -Rambutan-Gmelina	0.33 ± 0.11^a	0.46 ± 0.14^a	0.79 ± 0.22^a
Pineapple-Rambutan-Banana	0.33 ± 0.09^a	0.35 ± 0.11^a	0.67 ± 0.18^a
Pineapple-Indigenous Trees	0.48 ± 0.09^a	0.59 ± 0.11^a	1.08 ± 0.18^a

Note: LSD values with letter superscript (a) within columns of liniuan and bastos fiber have no significant differences; N = 18

CONCLUSION

The pineapple grown underneath the indigenous trees significantly ($p \leq 0.05$) produced lower dry biomass but higher fiber yield ($p \leq 0.05$) as compared to the other four production systems. However, no significant difference on fiber recovery was observed between study sites. On the other hand, pineapple-indigenous trees agroecological system had higher NPK contents compared to those in the other four production systems studied. Therefore, it is concluded that the pineapple–indigenous trees production was found out to be highly favorable and sustainable system for pineapple fiber production in Balete, Aklan, Philippines since this will lead to better soil fertility and provide optimum fiber yield.

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