Soil fertility and land suitability assessment of the different abaca growing areas in Leyte, Philippines

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Abstract
This study was conducted to assess the soil fertility status and land suitability of the different abaca growing areas of Leyte. Brief description of the sampling areas, agro-climatic data, and topographic parameters were recorded. Soil samples were collected and analyzed for the different soil fertility indicators. Soil pH, Available P, Exchangeable K, Exchangeable Ca, Extractable Cu, Extractable Zn and Extractable Fe were considered as MSFI for the different abaca-based production systems. Good relationships were observed in Avail. P (exponential), Exch. K (sigmoidal), Soil pH (quadratic), Ca, Fe, Cu (Gaussian) and Zn (logistic) that follows different patterns with respect to the biomass production of abaca. Samples collected at the mid-eastern portion of the island registered the highest SFI value of 8.05. FCC analysis suggests that more than three-fourths (i.e. 80%) of the sampling areas have Sandy soils while the modifiers revealed that acidity("h") is one of the major constraints for abaca production. Land suitability assessment of the sampling areas revealed that highly suitable (S_1) areas for abaca production are those found in north-western and mid-eastern portion of the island. There were areas identified as moderately suitable (S_2) for abaca production distributed throughout the province. Field fertilizer experiment in soils with some limitations (Paleudalf soil) revealed that fertilization significantly affected the growth performance and biomass production of abaca. N, P_2O_5 and K_2O application significantly influence the growth and biomass production of abaca.

Key Words
Soil fertility, land suitability, soil fertility index (SFI), soil fertility capability classification (FCC), abaca.

Introduction
Abaca is considered as one of the pillars among the export commodities of the Philippines from raw fiber, handicrafts, pulp and paper, and other related products. Aside from the raw fiber, manufactures is one of the important abaca-based products of which the Philippines is the sole exporter and has the edge over other producing countries. Likewise, the growing concerns for environmental protection and forest conservation of the whole world have further provided limitless opportunities to abaca-based raw materials. The country had been producing the greatest bulk of the global abaca fiber requirement for more than 5 years. In 2006, the country supplied nearly 85% of the global natural fiber requirement which accounted to not less than \$88M worth of exports (FAO 2007). However, majority of the abaca growing areas of the country is concentrated in hilly lands where fiber production and quality had been affected. Yield reduction due to continuous cultivation and lack of appropriate nutrient management could lead to soil degradation. Soil degradation is an anthropogenic process that has detrimental effect on the performance of the abaca plant. Soil fertility decline is believed to be the predominant degradation process occurring in most of the abaca growing areas. Intensive abaca cultivation in these areas has been done for more than two decades without applying any fertilizer as supplement to the crop. This would lead to the depletion of the nutrient reserve in the soil that would cause significant reduction of the fiber yield. Hence, assessment of the soil fertility and land suitability of the intensively cultivated areas in the province is one of the major concerns that would serve as bases in formulating research and development options in these areas.

Methods
In the process, samples were collected and analyzed as an input for the soil fertility capability classification (FCC), and soil fertility index (SFI) determination of the major abaca growing areas. In each sampling area, important features necessary for site characterization were gathered specifically on the different production systems dominant in the area. In each site, samples from the surface and sub-surface horizons that has the same soil type were collected and considered as a representative for a particular land-use type. These samples were analyzed for nutrient availability indicators based on the minimum data set (MDS) for soil fertility capability classification (FCC) and soil fertility index (SFI) determinations. These were quantified

based on soil pH, soil organic carbon, Total N, Avail. P, Exch. Bases (K, Ca, Mg, Na), CEC and Exch. acidity ($H^+ + Al^{3+}$). With these indicators, relationships between soil fertility and yield performance of abaca were determined. Soil fertility index (SFI) was obtained following the conceptual model developed by Andrews *et al.* (2004) while soil fertility capability classification (FCC) was done following the limits set by Sanchez *et al.* (2003). In like manner, suitability rating was done based on the available secondary data and analytical results. This was assessed based on soil property, topography climate and marketing factors. Information generated both from the soil fertility and land suitability assessment was used in the field fertilizer experiment conducted in soils with some limitations (Paleudalf soil). Results obtained in the field fertilizer experiment were the basis for the determination of the optimum performance of the abaca plant. Likewise, possible research and development options were formulated in relation to the different soil fertility indicators identified as possible determinants for sustainable abaca fiber production in Leyte province.

Results

Soil fertility assessment

There were two approaches used namely Soil Fertility Index (SFI) and Soil Fertility Capability Classification (FCC). Among the indicators, soil pH, Available P, Exchangeable K, Exchangeable Ca, Extractable Cu, Extractable Zn and Extractable Fe were selected as Minimum Soil Fertility Indicators (MSFI). With these indicators, samples collected in the southern part of the province was found to be high in soil pH that resulted to high availability of Ca in this area. Wide variability of P availability was noted which can be due to the extent of cultivation in these areas while the change in fertility level could be due to anthropogenic influence. Likewise, areas grown to abaca as monocrop and those grown to abaca in association with coconut have higher pH compared to areas with abaca grown in association with tree-legumes. When relationships were established between the identified MSFI, Avail. P(exponential), Exch. K (sigmoidal), Soil pH (i.e. quadratic), Ca, Fe, Cu (i.e. Gaussian) and Zn (logistic) follow different patterns with respect to the biomass production of abaca. Integrated scored value of the MSFI's revealed that among the areas sampled, east-central portion of the province showed the highest SFI value of 8.05. On the other hand the lowest SFI was noted in the northern part of the province with the value of 0.72. It was noted that this particular area exhibited a chronic problem of soil pH, Avail. P, Exchangeable K, Exchangeable Ca and Extractable Zn (Figure 1a). Following the FCC protocol, it was found that more than three-fourths (i.e. 80%) of the sampling areas have Sandy soils while the modifiers suggest that acidity is the major constraint for abaca production. Diagnostic report of the FCC system recommends that frequent small application of lime or K fertilizer will be used with close monitoring and appropriate use of soil test for those areas with some limitations. In extreme cases caused by acidity and aluminum toxicity, the use of Al tolerant crop varieties is also suggested.

Land suitability assessment

There were four factors considered for scoring in this particular assessment study. This includes the soil property, topography, climate and marketing factors. Result of the land suitability assessment showed that most of the sampling areas were moderately suitable for abaca production (Figure 1b). The highly suitable (S_1) areas are those sites located at the north-western and those in the east-central portions of the island. These areas are considered as highly suitable which could be attributed to the different factors associated to the scoring of values. There were also areas identified as moderately suitable (S_2) for abaca production distributed all-throughout the province. When all of these approaches were integrated (SFI, FCC and Land Suitability), it was noted that areas with very low soil fertility index were marginally suitable with a very minor limitation of Aluminum toxicity in the FCC system. An area in the east-central portion of the island obtained the highest suitability score (94.05) and was assessed as S_1 (i.e. highly suitable for abaca production).

Field fertilizer experiment in soils with some limitations

Data obtained from site characteristics, soil fertility and land suitability assessments were considered and served as basis in the development of an intervention through field fertilizer experiment for sustainable abaca production in Leyte. This was conducted in Paleudalf soil since this particular site was identified to have some fertility problems. It was observed that fertilization significantly influenced the growth performance and biomass production of abaca grown in this particular soil type. N, P and K application significantly improved the growth and biomass performance of abaca (Figure 2). However, biozome application (i.e. believed to be source of micronutrients blend with highly concentrated beneficial microorganisms) did not show any significant effect on the growth performance and biomass production of abaca

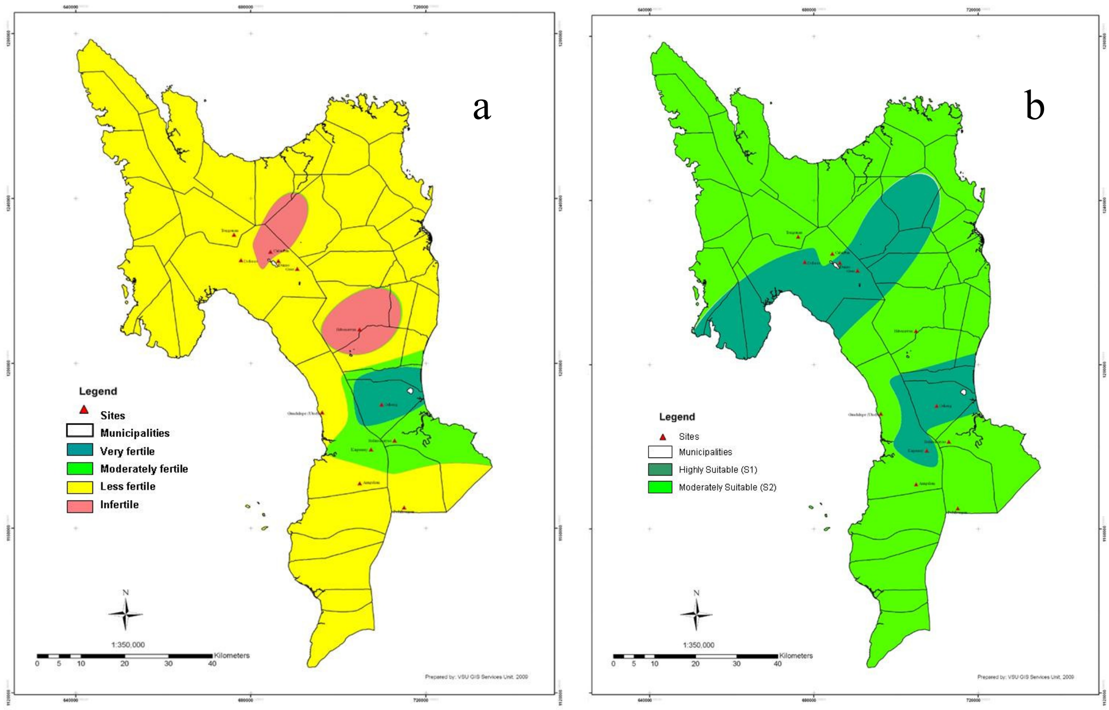

Figure 1. Soil fertility (a) and Land suitability (b) maps for abaca production in Leyte, Philippines.

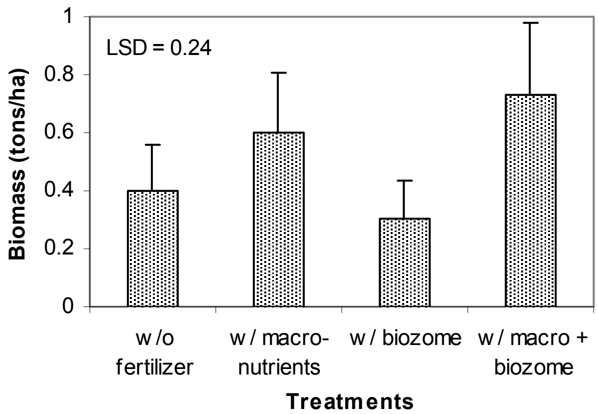

Figure 2. Biomass contents of abaca with applied macronutrients and biozome grown in Paleudalf soil (SE bars represent only the upper limit)

Suggested research and development options for abaca

Any research and development agenda should be feasible and holistic for sustainable nutrient management for abaca. A successful nutrient management planning should include assessment of the nutrient balance of the system, stakeholders involvement, and economic benefits of a particular intervention. It is envisioned that a more holistic nutrient management approach should focus on the limitations in the major abaca growing areas in Leyte. Research on lime application, which would help alleviate the nutrient availability (i.e. basic cations) and reduce aluminum toxicity should be taken into consideration. Another potential area for research is the development of acid or aluminum tolerant abaca varieties that could withstand areas with low soil pH.

Conclusions

Results from this scientific investigation proved that soil fertility is one of the causes of low productivity among the abaca growing areas in Leyte. Tools used in assessing the soil fertility conditions of the abaca growing areas in Leyte such as Soil Fertiliy Index (SFI) and Soil Fertility Capability Classification (FCC) were able to approximate the general fertility of soils planted to abaca. Likewise, integrating the SFI and FCC data can help assess the land suitability of the abaca growing areas in Leyte. In soils with some limitations (Paleudalf soil), N, P_2O_5, and K_2O application significantly improved the performance of abaca.

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