Assessment of major soil series grown to sugarcane under different land utilization types in Negros Occidental, Philippines

C A E Vallejera-Corsiga, R B Badayos, P B Sanchez, E S Paterno and P C Sta. Cruz

Department of Agricultural Science, Visayas State University-Villaba, Villaba, Leyte, Philippines 6537

E-mail: vallejera_19@yahoo.com; cleaanecorsiga@gmail.com

Abstract. Five major soil series that were planted to sugarcane namely Guimbalaon (Andic Haplustept), Isabela (AERIC Hapludalf), Luisiana (Ustic Palehumult), San Manuel (Fluventic Eutropept), and Silay (Aquic Tropudalf) were studied to identify the sugarcane-based land utilization types (LUTs) in Negros Occidental; determine the suitability of major soil series for sugarcane production; evaluate the possible soil constraints in sugarcane management; and draw soil management recommendations for sugarcane production based on soil constraints of major soil series. All of the soil series evaluated were classified as marginally suitable for sugarcane production, although soil constraints for production varied across series. Topography and wetness were the severe constraints common to all series. Soil management recommendations for constraints on topography in Guimbalaon (LUTs 4 and 1) and Luisiana(LUTs 1 and 2) series, were the implementation of a good soil conservation cropping and tillage practices such as contour terracing or farming. Moreover, problem on wetness in Isabela (LUTs 2, 5, and 6), San Manuel (LUTs 1 and 3), and Silay (LUTs 1, 2, 3, and 4) series could be managed by raising the height of the soil surface and elevate the site by adding 25-30cm of well-drained topsoil, compost or other organic matter to raise the planting zone and build drainage canals to direct water away from plants or other spots that collect water.

1. Introduction

Negros Occidental, known as the “Sugarbowl of the Philippines”, were the lifeblood of the economy is on sugar industry [1] and as the major sugar producer, contributes to more than half of the country’s total sugar production. Some 54 percent of its agricultural land is sugarcane-based, and raw sugar is its leading traditional export product. Today, much of the landscape of Negros Occidental remains in monoculture sugarcane production under the control of wealthy plantation owners known as “hacienderos”. Many landless laborers continue to toil in the cane fields for 1.50-2 US$/day and the cycle of poverty, indebtedness, and physically grueling works remain in the system [2].

Land evaluation provides a rational basis for the optimum use of land for sustainable production. It determines soil-based production constraints, sets corrective measures to improve yield, and suggests ideas for possible alternative land uses [3]. Land utilization studies are important procedures in land
evaluation and it plays a balancing role in soils, land mapping, and resource survey. Land Utilization Type (LUT) consists of a set of technical specifications within a socio-economic setting [4]. Relatively, proper land quality evaluation generates a more specific land utilization type (LUT) to which spatial and climatic variability are recognized. It also provides sound management recommendations to bridge the gap between land quality and land quality requirements. On the other hand, inappropriate land use leads to inefficient exploitation of natural resources, destruction of the land resource, poverty and other social problems.

Thus, this study aimed to identify the sugarcane-based land utilization types in Negros Occidental; determine the suitability of major soil series for sugarcane production; evaluate the possible soil constraints in sugarcane management; and draw soil management recommendations for sugarcane production based on soil constraints of major soil series.

2. Materials and Methods

2.1. Survey, assessment, and selection of the study sites

A comprehensive assessment was conducted on sugarcane areas in the province. Topographic, geologic, and soil maps as well as other publications, were used as materials in identifying the sampling sites. Major soil series grown to sugarcane were identified and utilized in this study. Out of the nine (9) soil series planted to sugarcane in Negros Occidental, five (5) soil series (Guimbalaon, Luisiana, Isabela, San Manuel, Silay), were comprehensively assessed and utilized in this study since these are the most widespread soil series found in the province.

2.2. Soil collection and laboratory analysis

Twenty soil samples were collected from representative sites at depths of 0-30 and 30 – 60cm and were processed and analyzed in the laboratory for soil pH, total N, available P, exchangeable bases, percent organic carbon, extractable Fe, exchangeable Al, particle size distribution, and cation exchange capacity following standard procedures.

2.3. Soil data and climatic characteristics collection

Data on soil and climatic characteristics of the soil series being studied were collected from available references. Simplified Keys to Soil Series of Negros Occidental [5] and Soil Survey Reports of Negros Occidental [6] were used as references for most of the soil characteristics. Climatic characteristics of each soil series were obtained from www.en.climate-data.org.

2.4. Identification of land utilization types (LUTs)

Existing Land Utilization Types (LUTs) in the study areas were identified through farm survey and verified through field inspection. An interview of five (5) sugarcane farmers in each soil series was done in order to know the history of the land being cultivated especially on the number of years the land was planted with sugarcane and the management practices being used. Results collected from the interview were used in grouping the extensively and less extensively managed sugarcane areas as well as irrigated and non-irrigated management scheme for each soil series. Each LUT was identified with its corresponding management attributes using the FAO framework. These include cropping system or pattern, farm size, land tenure, crop variety, cultural management practices (e.g. fertilizer input and use, crop protection), irrigation system, labor intensity, power, mechanization, farm inputs, crop yield, capital intensity, livestock, farm sales, technical knowledge, and market orientation.

2.5. Suitability evaluation and constraint analyses

Soil and climatic characteristics of the five soil series (Guimbalaon, Isabela, Luisiana, San Manuel, Silay) were matched with the criteria set by Sys, Ranst, Debaveye and Beernaert [7] for sugarcane requirements to determine their suitability class. The matching utilized the FAO land evaluation system using the following interpretations for suitability classes:
3. Results and Discussion

3.1. Description of land utilization types (LUTs) identified in Negros Occidental

According to FAO [4] and Sys et al [8], an LUT is a specific subdivision of a major kind of land-use, serving as the subject of land evaluation and defined as precisely as possible in terms of produce and management. The land utilization type should not only define the crop or crop rotation (produce), but in addition, it has to precisely how to farm these crops (management). This implies that the concept of “Land Utilization Type” includes the kind of crop, the succession of crops in a rotation or farming system with precision of the management type.

In the study area, six (6) LUTs were identified based on the soil series and sugarcane cultivation and management practices. The extent and distribution of these LUTs were mapped and shown in Figure 1.

- **LUT 1** – with intermediate level of farm technology producing sugarcane in a monocropping cropping pattern with farm sizes ranging from 1.16 – 7.0 hectares. Farm practices were based on power-driven implements particularly on land preparation including plowing, harrowing and furrowing by using tractors during at plant cane and animal-driven using carabao at 1st and 2nd ratoon while the rest of the farm operations such as planting, fertilization, weeding, pesticide application, and harvesting were done manually thus requiring high labor intensity. Irrigation system was carried out by fuel-driven machine to irrigate the crops. Capital intensity is higher which is brought about by high cost of farm production inputs. Soils that belong to this LUT were Guimbalaon, Luisiana, San Manuel, and Silay soil series.

- **LUT 2** – with intermediate level of farm technology producing sugarcane that are mainly rain-fed in a monocropping cropping pattern with farm sizes ranging from 0.70 – 3.60 hectares. Farm practices were based on power-driven implements particularly on land preparation including plowing, harrowing and furrowing by using tractors during at plant cane and animal-driven using carabao at 1st and 2nd ratoon while the rest of the farm operations such as planting, fertilization, weeding, pesticide application, and harvesting were done manually thus requiring high labor intensity. Irrigation system was carried out by fuel-driven machine to irrigate the crops. Capital intensity is higher which is brought about by high cost of farm production inputs. Soils that belong to this LUT were Guimbalaon, Luisiana, San Manuel, and Silay soil series.

- **LUT 3** – with intermediate level of farm technology producing sugarcane that are mainly rain-fed in a crop rotation cropping pattern with farm sizes ranging from 1.0 – 1.10 hectares. Farm practices were based on power-driven implements particularly on land preparation including plowing, harrowing and furrowing by using tractors during at plant cane and animal-driven using carabao at 1st and 2nd ratoon while the rest of the farm operations such as planting, fertilization, weeding,
pesticide application, and harvesting were done manually thus requiring high labor intensity. Capital intensity brought about by the cost of farm production inputs is moderate. Soils found in this LUT were San Manuel and Silay soil series.

• LUT 4 – with intermediate level of farm technology producing sugarcane that are mainly rain-fed using a monocropping cropping pattern with farm sizes ranging from 0.3 – 0.5 hectares. Farm practices were based on carabao-drawn implements particularly on land preparation including plowing, harrowing and furrowing during at plant cane and 1\textsuperscript{st} and 2\textsuperscript{nd} ratoon while the rest of the farm operations such as planting, fertilization, weeding, and harvesting were done manually requiring low labor intensity due to smaller sizes of the farm. In addition, lower amounts of fertilizers were applied hence requires lower capital intensity for the cost of production inputs. Guimbalaon and Silay series belong to this LUT.

• LUT 5 – with intermediate level of farm technology producing sugarcane using a crop rotation cropping pattern with a farm size of 0.5 hectares. Farm practices were based on carabao-drawn implements particularly on land preparation including plowing, harrowing and furrowing during at plant cane and 1\textsuperscript{st} and 2\textsuperscript{nd} ratoon while the rest of the farm operations such as planting, fertilization, weeding, and harvesting were done manually requiring low labor intensity due to smaller size of the farm. Irrigation system was carried out by fuel-driven machine to irrigate the crops. Capital intensity is high which is brought about by high cost of farm production inputs. Soils under this LUT belong to Isabela series.

• LUT 6 – with intermediate level of farm technology producing sugarcane using a monocropping cropping pattern with a farm size of 2.0 hectares. Farm practices were based on carabao-drawn implements particularly on land preparation including plowing, harrowing and furrowing during at plant cane and 1\textsuperscript{st} and 2\textsuperscript{nd} ratoon while the rest of the farm operations such as planting, fertilization, weeding, and harvesting were done manually requiring high labor intensity. Irrigation system was carried out by fuel-driven machine to irrigate the crops. Capital intensity is high which is brought about by high cost of farm production inputs. Isabela series belongs to this LUT.

**Figure 1.** Extent and distribution of sugarcane-based land utilization type in Negros Occidental, Philippines.
3.2. Suitability evaluation of major soil series grown to sugarcane

The evaluation applies the information on topography (t), wetness (w), physical soil characteristics (s), soil fertility characteristics (f), and climate (c) of the different major soil series under study which was matched to the standard crop requirement of sugarcane-based on Land Evaluation of Sys et al [7] involving climate, landscape, and soil conditions. Each parameter acquired by the different soil series were rated as highly suitable (S1), moderately suitable (S2), marginally suitable (S3), currently not suitable (N1), and permanently not suitable (N2).

Based on the results, each soil series have different suitability concerning the different parameters mentioned. Suitability map as shown in Figure 2 revealed that all soil series, namely, Guimbalaon, Isabela, Luisiana, San Manuel, and Silay were classified as marginally suitable (S3) however, a limitation for sugarcane production varies in each soil series. Soils that were not studied and found on the map were indicated as others.

3.3. Crop constraints analysis of major soil series grown to sugarcane

The suitability ratings were utilized in the determination of the limitations or constraints of the crop from the different soil series under study. Based on the results, topography and wetness became the severe constraints for most of the soils (Figure 3). Nevertheless, climate specifically relative humidity (RH) was observed to be the common factor for all soil series which moderately limit production of sugarcane since it exceeded the maximum requirement of humidity needed by the crop. Other factors noted were physical soil characteristics and fertility, however, a limitation is moderate and manageable.

Isabela, San Manuel, and Silay series have problems with wetness due to its seasonal flooding occurrences. On the other hand, Guimbalaon and Luisiana series have a constraint on topography because of its rolling to hilly to a mountainous topographic position.

![Figure 2. Suitability map of major soil series grown to sugarcane in Negros Occidental, Philippines.](image-url)
Figure 3. Constraints map of major soil series grown to sugarcane in Negros Occidental, Philippines.

3.4. Soil management recommendations based on soil constraints

Appropriate soil management practices were recommended to address the problems or constraints of each soil series that may limit sugarcane production. Constraints on topography as identified in Guimbalaon and Luisiana soil series (LUTs 1, 2, and 4) could be alleviated by implementing good soil conservation cropping and tillage practices such as contour terracing. Problems on wetness due to flooding and poor drainage observed in Isabela, San Manuel, and Silay soil series could be alleviated by raising the height of the soil and elevating the site by adding 25-30cm of well-drained topsoil, compost or other organic matter to raise the planting zone, build drainage canals to direct water away from plants or other spots that collect water, construct broad beds, ridges or furrows, and addition of an organic substance into the soil to improve the water-holding capacity of the soil. Furthermore, limitations on fertility and physical soil characteristics were moderate and manageable. On the other hand, climatic constraint specifically on high relative humidity of the area can be addressed through proper scheduling of farm activities.

4. Conclusion

Based on the results of the study, six (6) LUTs were identified based on the soil series and sugarcane cultivation and management practices in the province. Conventional farming operation was practiced in all LUTs either through semi-mechanized or purely animal-drawn land preparation with intermediate level of farm technology intervention. LUTs 1, 2, 4, and 6 were on monocropping pattern that uses fuel-driven irrigation system except for LUT 2 that depends on a rainfed-based irrigation system whilst LUTs 3 and 5 practiced a crop rotation pattern where the former uses a rainfed-based irrigation system and the latter uses a fuel-driven irrigation system. Guimbalaon, Isabela, Luisiana, San Manuel, and Silay soil series were classified as marginally suitable (S3) for sugarcane production although, soil constraints varied across soil series. Topography and wetness became the severe constraints for most of the soils however, limitation for fertility and physical soil characteristics were considered moderate and manageable.
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