CHAPTER 3

MATERIALS AND METHODS

This study consists of three parts: 1) a field survey in Myanmar, 2) a field experiment in Thailand, and, 3) a simulation of sugarcane response to different nitrogen management at different water regimes, as testing of a nitrogen sub-model which was incorporated into CANEGRO-DSSAT model. The first part intended to gain understanding and identify constraints of the current sugarcane production system and current farmers' practices in sugarcane cultivation and their nutrient management. Secondly, the field experiment was developed based on the results of first part to improve nitrogen fertilization which was set up to examine the effect of basal nitrogen application under different moisture regimes in early growth stages of sugarcane. Thirdly, the CANEGRO-DSSAT (v3.5) incorporated a nitrogen sub-model was tested against with the observed data from the field experiment in order to capture the model's predictions on the sugarcane responses to nitrogen, under different water management systems. The model may help in making decision on such management to choose the best alternative. The details of above all parts are described in the following sections.

3.1. Field survey

The field survey was carried out to gain understanding about sugarcane cropping systems and patterns, current farmers' practices in sugarcane-based cropping systems. It allowed access the various forms of limiting factors of cane yields and socio-economic constraints for cane production in the study area. The survey was carried out during March to May 2001 in Myanmar.

Four villages were selected for field survey, namely Letpandaw (LPD), Zayitchaung (ZYC), Lebe (LB) and Thanpayachone Village (TPC). The selection was based on soil-types and recorded sugarcane yields. The villages locate in the Southern, Western, North-Eastern and Northern of the township. The information about sugarcane cultivation area, productivity, and soil survey reports were collected from respective Government Departments. Twenty households that growing sugarcane crop in each village were randomly chosen for the formal survey with questionnaires. The information on agricultural land use, cropping systems and sugarcane grown area, fertilizer management on sugarcane, cane yields and constraints for production were designed in questionnaires of formal survey. Secondary data on physical feature, land uses of the township and climatic conditions such as rainfall, temperature were collected from responsible authorities.

Soil tests from sugarcane growing area where respective to selected villages were done. During this survey, soil samples were collected as composite samples from the fields of survey sites with farmers' participation. Composite soil samples were determined based on formal information from soil map of region (Land Use Department, 1959) and informal information from farmers, i.e., how soils distribute in the fields in term of color, texture and fertility status. Farmers have their own soil classification system mostly based on color and texture. Randomized 10-15 soil samples for each different soil types within each field, to the depth of 25 cm were collected as the first step. And then soil samples under the same group of soil type were mixed together to get one composite soil sample. Composites samples were collected from field number: 401, 402, 383, 382; where sugarcane growing area of Zayitchang (ZYC) site, number 796, 797, 798; where cane growing area of Letpandaw (LPD) site, field number 301,300, 302; where cane growing area of Lebe (LB) site, and plot number 8, 10, 15, 25; where sugarcane growing area of Thanpayachone (TPC) site. Composite soil samples were sent to the soil laboratory of Land Used Department and analyzed for organic matter content, organic carbon content, total nitrogen, available P_2O_5 and K_2O, exchangeable cations (Ca, K, Mg), pH, soil texture, and EC.

3.2. Field Experiment

3.2.1 Experimental site

A field experiment was conducted in the Irrigated Experimental Station of Multiple Cropping Center, Faculty of Agriculture, Chiang Mai University located at North latitude 18° 46′ and East longitude 98° 57′ at 1035 feet above sea level, during January to April 2002.

3.2.2. Experimental design

The experiment was arranged in a split-plot design with three replications, water regimes served as the main plot and nitrogen fertilizer application served as the sub plot. The two main plots were rainfed and fully irrigated based on sugarcane crop requirement with weekly interval. The four subplots were four nitrogen rates, which were 0,100, 200 and 400 kg N ha^{-1}. Urea fertilizer (46% nitrogen) was used as the nitrogen source.

3.2.3. Field management

Single cane setts of sugarcane cultivar (U-Thong 5) were pre-germinated, on January 18, 2002, in plastic bags and transplanted on February 18, 2002, when the sugarcane seedlings reached their fifth leave stage, at 30 x 30 cm spacing to take advantages of weed control. Weeds were manually controlled in the plots. Specific urea fertilizer rate was applied at transplanting, by mixing the fertilizer with the soil. For rainfed plots, uniform soil moisture (0.5-liter $plant^{-1}$) was applied at the day after transplanting. For irrigated plots were irrigated with estimated crop water requirement for one week, when the day after transplanting. Regular irrigation was applied, scheduled in weekly with estimated crop water requirement. The required amount of water for irrigation treatment plots was irrigated by using tap-pipe system with measuring volume of water (liter sec^{-1}). Regular irrigation was applied for the irrigation plots with one-week interval. The amount of water for irrigation plot was calculated based on the crop coefficient value (Kc) for respective crop growth stage and evaporation of American class A pan (E pan). The estimated amount of irrigated water volume was calculated using following equations (FAO, 1977):

ETo = Kp * E pan

ET crop = Kc * ETo

Where:

ETo = Evapotranspiration

Kp = Coefficient of Class A pan

Epan = Mean evaporation of pan (mm day^{-1}) of the interested period

Kc = Coefficient of crop growth stage or crop coefficient

3.2.4. Sampling procedures

3.2.4.1. Plant samples

Plant samples were collected five times at a 15-day interval, started from 28th, February 2002 until end of April 2002.

Sugarcane roots

Sugarcane roots were assessed at three soil depths (0-5, 5-10 and 10-15 cm) using a spade, a hoe and a sharp knife. Soil cores were manually broken up and fleshy roots were removed. Root lengths at different depth were measured with hand ruler after washing with clean tap water. And also above ground plants samples were collected at the same time. All root measurements were made with ambient light supplied by overhead florescent lamps. Fleshy root length density (F-RLD) was calculated from following equation:

$$F-RLD=\frac{L}{V}(cm.cm^{-3}) \quad \text{... ... ...} (1)$$

Where: L is the fleshy root length, and V is the volume of the soil core.

Dry matter weight

Plant samples were separated into root and top parts and then oven dried at 70°C for 48 hours. Plant samples were measured for dry matter weight of each part.

Total nitrogen content

Well-dried roots and shoots were grinded and analyzed for total nitrogen content in each part. The total nitrogen contents in each part were determined by Kjeldahl method. In addition, root length and dry weight in plant parts at transplanting were measured, weighted, and analyzed nitrogen content of each part.

Number of tillers and Leaf Area

The number of tillers per hill was manually counted at the last two sampling dates, and measured for the leaf Area. The specific area cuts of sample leaves were weight. Total leaves were weighted and then calculation from the known area (dm^2), the weight and the total leaf weight estimated the leaf area (m^2).

Efficiency of nitrogen fertilization

The agronomic or economic efficiency was calculated for observed variable; yield of above ground biomass. Efficiencies of nitrogen fertilization were calculated by following equations (Craswell and Godwin, 1984);

$$\text{Agronomic efficiency} = \frac{\text{Crop yield F - Crop yield C}}{\text{N applied}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

$$\text{Physiological efficiency} = \frac{\text{Crop yieldF} - \text{Crop yieldC}}{\text{N uptakeF} - \text{N uptakeC}} \quad \ldots\ldots\ldots\ldots\ldots\ldots(3)$$

$$\text{Fertilizer use efficiency} = \frac{N\ uptakeF - N\ uptakeC}{N\ applied} \quad \ldots\ldots\ldots\ldots\ldots\ldots(4)$$

Where F= fertilized crop and C= unfertilized control

3.2.4.2. Soil samples

At the beginning of the experiment, composite soil samples were collected from the field at two soil depths before transplanting. Then, examined for soil pH, soil moisture, bulk density, content of total nitrogen, available phosphorous and potassium, exchangeable Ca, Mg and Mn. After experimentation, soil samples were taken from individual plot, and examined for residual total N content and pH.

3.2.4.3. Minimum data set for simulation using DSSAT v3.5

Based on Hunt and Boote (1998) and Tsuji *et al.* (1994), the minimum data sets for a site, including weather, soil parameters, genetic parameter and management practices were specified for DSSAT v (3.5) application. The required minimum data sets of experimental site at Chiang Mai were entered into DSSAT format. The simulated results of the effect of nitrogen application on crop growth under moisture regimes were compared with real observed data as model testing.

3.2.5. Data analysis

Field survey

The results from the formal survey and interview were analyzed by using descriptive statistics. Percentage, mean standard error of the mean, and CV% were used for the analysis of data on information of survey results regarding to fertilizer and nutrient management and cultural practices. Gross margin analysis was used to compare cropping systems in the study area in term of economic benefits.

Field experiment

Collected data sets were analyzed by using the standard statistical analysis methods: descriptive statistics, and analysis of variance (ANOVA) and compare with Least Square Deviation (LSD).

Simulation

An existing sugarcane simulation model (CANEGRO-DSSAT) incorporated with a nitrogen sub-model was used to simulate the effects of water and nitrogen on the early growth stages of sugarcane for the experimental site. The results of simulation and observed data sets of the field experiment were compared by using Mean Square Deviation (MSD) statistics suggested by Kobayashi and Salam (2000) and descriptive statistics. Mean Square Deviation is the sum of the three components; Square Bias (SB), Square difference by Standard Deviations (SDSD), and the lack of correlation weighted by the Standard Deviation (LCS).

The difference between the simulation and the measurement is calculated with the MSD as;

$$MSD = \frac{1}{n}\sum_{i=1}^{n}(x_i - y_i)^2 \qquad \dots\dots\dots\dots\dots (5)$$

The bias of the simulation from measurement, denoted by SB, calculated as;

$$SB = (\bar{x} - \bar{y})^2 \qquad \dots\dots\dots\dots\dots (6)$$

Square difference by Standard Deviations (SDSD) describes that the magnitude of fluctuation among the *n* measurement of simulation by model, is calculated as follow;

$$SDSD = (SD_s - SD_m)^2 \qquad \text{... ... ... (7)}$$

The components; Standard Deviation of simulation (SD*s*) and Standard Deviation of measurements (SD*m*), of above equation were calculated using following equations;

$$SD_s = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad \text{... ... ... (8)}$$

$$SD_m = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(y_i - \bar{y})^2} \qquad \text{... ... ... (9)}$$

The lack of positive correlation weighted by standard deviation, denoted as LCS, describe the simulation pattern of the fluctuation across the *n* measurements. It is calculated as;

$$LCS = 2SD_s SD_m (1 - r) \qquad \text{... ... ... (10)}$$

Where: r = coefficient between simulation and measurement, calculated as;

$$r = \left[\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})\right] \Big/ (SD_s - SD_m) \qquad \text{... ... ... (11)}$$

The difference between the simulation and measurement with respect to the deviation from means, denoted as MSV is calculated as follow:

$$MSV = \frac{1}{n}\sum_{i=1}^{n}\left[(x_i - \bar{x})(y_i - \bar{y})\right]^2 \qquad \text{... ... ... (12)}$$

The high MSV indicates that the model failed to simulate the variability of the measurement around the mean.