CANEFERT 1.0: A CHEMICAL FERTILISER RECOMMENDATION SOFTWARE FOR SUGARCANE PRODUCTION IN THAILAND

By

P. PRAMMANEE¹, A. JINTRAWET², C. LAIRUNGREUNG¹
and S. KONGTON³

¹Suphanburi Field Crops Research Center, U-Thong Suphanburi 72160 Thailand
²Chiangmai University, Chiangmai, 20000, Thailand
³Soil Survey and Classification Division, Department of Land Development Bangkok 10900

Email: pramm@access.inet.co.th

KEYWORDS: Fertiliser Recommendation, Simulation Model, Soil Analysis.

Abstract

CHEMICAL fertiliser accounts for a substantial part of sugarcane production costs in Thailand, where most cane growers lack basic knowledge regarding the use of fertilisers. A computer program, CaneFert 1.0, is being developed to accurately determine recommendations for the application of N, P and K using the properties of the soils under sugarcane production throughout Thailand. The project includes: sugarcane soil identification using soil series maps; field surveys to confirm the identification; determination of nutrient requirements; cane growth simulation using CANEGRO 3.5 to determine the effect of water and nitrogen; economic analyses of chemical fertiliser recommendations and validation trials to confirm the recommendations generated by CaneFert 1.0. The resulting software allows users to identify the site by pointing an arrow on a map displayed on the computer screen. The farm’s location, soil series, soil chemical properties, N-P-K requirements, and the amount and method of chemical fertiliser application are also generated. It is anticipated that sugar mills, sugarcane grower associations, government agencies, agronomists, and extension workers will use this software.

Introduction

Thailand currently imports more than US$750 million worth of chemical fertilisers, the cost of which accounts for a substantial proportion (8–12%) of the cost of sugarcane production. While production costs increase, the price of sugar on the world market decreases, which causes severe problems to the Thai sugar industry, compounded by the misapplication of fertilisers by cane growers; the efficiency of fertiliser use is commonly reported as being less than 40% (Prammanee et al., 1999).

Similar low recoveries of fertiliser N have also been reported for sugarcane in South Africa (Wood, 1990), Hawaii (Stanford et al., 1965) and India (Yadav et al., 1990). In addition, the increase in fertiliser use can aggravate problems of soil acidification, contamination of ground and surface water and enhance greenhouse gas emissions.

Prammanee et al. (1997) reported that less than 6% of cane growers in Thailand have a basic knowledge of chemical fertiliser use and application.

A chemical fertiliser recommendation system for sugarcane production is needed to accurately determine requirements for chemical fertiliser. The aim of the project described in this paper is to determine suitable sugarcane growing zones, based on soil type and climatic data that will be incorporated into computer software (CaneFert 1.0) to provide fertiliser recommendations.

The properties of every soil series found in the area growing sugarcane in 46 provinces were compiled to determine N, P, and K requirements and field surveys were conducted to ascertain/verify the various soil classifications and the sugarcane yields obtained.

The potential of each soil type, weather, and management needs was considered in making basic recommendations using the sugarcane simulation model, CANEGRO 3.5. This model can be used to predict sugarcane yield under various N and water management schemes (O’Leary, 2000) The economic analysis of fertiliser application in each soil series will also be performed.
Materials and methods

The development of CaneFert 1.0 required the following 9 experimental procedures:

1. Cane soil identification

Digital satellite images (LANDAST 5th) of sugarcane planting areas were overlayed with a soil group map (SoilView 2.0) by the identity method using Arcview 3.1 software. The output software (CANESOIL 1.0) can identify all the soil groups of the entire sugarcane growing area, which was further divided into soil series.

2. Field survey to confirm the identification

Soil surveys in sugarcane fields were conducted in 5 provinces of the northeast and 9 provinces of the central and northern areas. In total, 76 sugarcane farms were surveyed. Simple soil survey and classification methods were used. Soil horizon arrangement, soil colour, soil texture, soil horizon depth and topography were used to identify soils to 100 cm depth at each location.

3. Survey of sugarcane yield, soil identification and its location using global positioning satellite (GPS) system

Sugarcane yield and juice quality were determined for the 31 cane farms of 10 provinces in the northeastern area and 15 cane farms of 10 provinces in the north and central areas. The harvested plots at each site were replicated four times. The soils at each site were sampled and identified for series classification in the soil database of the Department of Land Development (DLD).

The location of each sampling spot was marked by GPS using Trimble Geoexplorer 3C (Trimble Navigation Limited, USA) and Garmin III plus (Garmin International Kansas USA). The GPS coordinators were in the UTM system and were plotted in the digital soil series map (SoilView version 2.0) of the DLD.

4. Nutrient requirement of each soil series determined by its properties

After the soil had been identified, its properties were also classified using the established soil series in the Northeast, Central Plain, North and Central Highland of Thailand, and these were reclassified according to Soil Survey Staff (1998). The recommended N, P, and K rates were based on soil organic matter and inorganic nitrogen (Keeney and Nelson, 1982), Bray II available phosphorus (Murphy and Riley, 1962) and exchangeable K (Knudsen et al., 1982).

5. Using CANEGRO 3.5 to determine the effect of nitrogen and irrigation on sugarcane yield and comparison of actual and simulated yield

Actual sugarcane yield was sampled from the 31 cane farms of 10 provinces in the northeast and 15 cane farms in the north and central areas. The location of each sampling spot was determined using GPS. Sugarcane yields under various nitrogen and water management regimes were simulated using CANEGRO 3.5 in DSSAT 3.0.

The input file included the genetic coefficient of two Thai cane varieties K 84-200 and UT2. The weather data of each location contained the daily maximum and minimum temperatures, rainfall and solar radiation. Soil data of each location was obtained from the soil survey report (Kongton et al., 2002) containing the minimum data set for simulation. The effect of N and water application was determined by comparison of simulated and actual yield.

6. Correlation between soil chemical properties and sugarcane yield

Sugarcane was sampled from the 31 cane farms in the northeast and 15 cane farms in the north and central areas. Fresh stalk yield, yield components and juice quality of each sample were measured. Soil was also sampled for its chemical and physical properties such as pH, organic matter, ammonium, nitrate, P, K, bulk density, electrical conductivity, and clay content.

Sugarcane yield, yield components, and juice quality were correlated with soil properties in order to determine the influence of soil properties on yield.

7. Economic analysis for chemical fertiliser recommendation

The economic analysis for chemical fertiliser recommendation in each soil series was performed in DSSAT 3.0 using the Mean Gini Dominance (MGD) analysis method (Tsuji et al., 1994).

For the two risky prospect, A and B, A dominates B by MGD if

$$E(A) \geq E(B) \text{ and } E(A) - G(A) = E(B) - G(B)$$

(1)
Where $E(A)$ is the mean of distribution (treatment) A, $E(B)$ is the mean of distribution B, $G(A)$ is the Gini coefficient of distribution A, $G(B)$ is the Gini coefficient of distribution B.

The cost of production includes variable cost and fixed cost such as labour, fertiliser, fuel chemicals, land costs and taxation.

8. The fertiliser trial to confirm the recommendation of CaneFert 1.0

The trial was conducted on 12 sugarcane farms in the northeast, 2 farms in the north and 9 farms in the central area. The soils at the site were varied but represented the major soil series of sugarcane production areas. The trial was initiated in October 2001 in the northeast and January 2002 in the north and central areas. The experimental design was a randomised complete block with 4 replications. The 6 fertiliser treatments being tested were: 1) control (no fertiliser), 2) farmer practice, 3) general recommendation, 4) 50% recommendation by CaneFert 1.0, 5) 100% recommendation by CaneFert 1.0, and 6) 150% recommendation by CaneFert 1.0. The trials were harvested in January 2003.

9. CaneFert 1.0 software production

The CaneFert 1.0 is a Windows-based interface that allows users to place limits on the size of the area to be used to define fertiliser application practice and to display the name of the soil series and its properties. The core databases of the CaneFert 1.0 system include a digitised soil series map at the 1:50000 scale (Soilview 2.0, Department of Land Development), soil attribute data sets, maps of administrative boundaries and required rates for N, P and K application. These data and models are manipulated spatially. The file structure for the CaneFert 1.0 interface is shown in Figure 1.

Results

Using CaneSoil 1.0 allows the identification of sugarcane soil series in the sugarcane production areas of 46 provinces. It was found that, in the central area, soil group No. 33 was a major soil series for this sugarcane planting area. This represents the soil series group known as the Kampangsean soil series (Fine, silty mixed, Typic Haplustalfs), and occupies 14,200, 14,400, and 6,900 ha in three of the main sugarcane production areas of the west (Kanchanaburi, Suphanburi and Nakon Patom Provinces, respectively). This soil is fertile and suitable for sugarcane.

Not many soil series were found in the northeast. The most important is soil group No. 40. The major soil series represented in this group cover the largest areas in many of the provinces, such as Yangtalat series (Coarse loamy, siliceous, nonacid, Ustoxic Dystropepts), and Sanpatong series (coarse
loamy, mixed, Ustoxic Dystropepts) occupy 31600, 30 900, 8800, and 19 500 ha in four main northeast cane production areas (Udonthani, Nakon Rachasima, Khon Kaen and Kalasin, respectively). These soil series are also low in fertility and fertiliser management is very important to increase cane yield.

Field surveys to confirm the identification given by CaneSoil 1.0, indicated that 71% of the central sugarcane growing area was correct and 62% of northeastern area was correct and thus acceptable for the present purposes. When sugarcane yield, soil properties and nutrient requirement were considered, it was found that most of the cane farmers applied chemical fertiliser that inadequately met the requirements for their soil, particularly in the low fertility soils of the northeast.

Using CANEGRO 3.5 to simulate sugarcane yield under 4 levels of limitation (N and irrigation management), the simulated sugarcane yields of each location varied according to the influence of soil properties and rainfall. However, they were in keeping with the actual yield from the farmers. The simulated sugarcane yields demonstrated the capacity of each soil series and weather to influence sugarcane yield potential. At two farms of the northern area in sandy soil (Satuk series: fine loamy, kaolinitic, Typic Paleustult), the observed cane yields were 111.9 and 101.3 t/ha compared with 45.0 and 51.3 t/ha from simulation without N and irrigation.

Economic analyses were performed for the major soil series. It was found that applications of fertiliser according to soil analysis and recommended by CaneFert 1.0 provided the highest returns. However, the application rates can be increased up to 150% of the CaneFert 1.0. This application rate gave a maximum cane yield and (100 and 150% CaneFert) were the only two treatments that were acceptable by the Mean Gini dominance (MGD) analysis (Y).

The results of validation trials showed that basing fertilisation recommendations on CaneFert 1.0 resulted in maximum cane yields in 7 of 20 trials with cane yield using CaneFert 1.0 being higher than farmer practices in 14 of these trials.

Discussion and conclusions

Soil identification indicated that there were not many different major soil series in the million ha of sugarcane planted in Thailand. Sugarcane soils in the northeast generally have low fertility and need more N, P and K than those in the central region. Using DSSAT-Canegro 3.5 showed the opportunities that are available to increase sugarcane yield in each soil series by N and water management. However, cane yields differed from actual yield as the addition of N and water in the sub-model still needs to be developed. This should be comparable with modelling work in Australia where APSIM sugarcane adds the N variable (O’Leary, 2000). CaneFert 1.0 was developed using a programming language within the GIS package that allows users to select the location of their farm on a digital map. When the arrow is pointed to the farm’s location on the map, CaneFert 1.0 will identify the soil series, its chemical properties, the amounts of N, P, and K to apply and the expected cane yield. The program is convenient to use and can assist cane farmers, extension workers, agronomists and administrative people to manage their chemical fertiliser application appropriately. CaneFert 1.0 will increase the precision of fertiliser usage, increase the efficiency of the fertiliser used, reduce the contamination of ground and surface water and, most importantly, will allow the cane growers to be more profitable.

Acknowledgements

The research team thanks the Thailand Research Fund (TRF) for financial support during August 2000–July 2003. We thank all the cane growers for allowing us to survey and establish experimental sites on their farms. The authors would like to express the sincere thanks to Suphanburi Field Crops Research Center who provided support and the necessary facilities that allowed us to carry out this work.

REFERENCES


201


CANEFERT 1.0 : UN LOGICIEL POUR LA RECOMMANDATION D’ENGRAIS CHIMIQUES DANS LA PRODUCTION DE LA CANNE À SUCRE EN THAÏLANDE

P. PRAMMANEE1, A. JINTRAWET2, C. LAIRUNGREUNG1 et S. KONGTON3

1Suphanburi Field Crops Research Center, U-Thong Suphanburi 72160 Thailand
2Chaingmai University, Chaingmai, 20000, Thailand
3Soil Survey and Classification Division, Department of Land Development Bangkok 10900

Email: pramn@access.inet.co.th


Résumé

LES ENGRAIS chimiques représentent un coût substantiel dans la production de la canne à sucre en Thaïlande, où la plupart des cultivateurs de canne à sucre n’ont pas de connaissance de base sur l’utilisation d’engrais. Le logiciel, CaneFert 1.0, a été développé pour déterminer avec précision des recommandations pour l’application de N, P et K en utilisant les propriétés des terres où sont cultivé la canne à sucre dans l’ensemble de la Thaïlande. Le projet comprend: (i) identification des terres à canne à sucre en utilisant des cartes de type de sol; (ii) des visites aux champs pour confirmer l’identification; (iii) la détermination des besoins nutritifs; (iv) la simulation de la croissance de la canne en utilisant CANEGRO 3.5 pour déterminer l’effet de l’eau et celui de l’azote et (v) une analyse économique pour les recommandations d’engrais et des essais pour valider les recommandations produites par CaneFert 1.0. Le logiciel final permet aux utilisateurs d’identifier le site en dirigeant une flèche sur une carte affichée sur l’écran de l’ordinateur. La localisation de la ferme, le type de sol, les propriétés chimiques du sol, les besoins en éléments nutritifs N-P-K, la quantité et la méthode d’application de l’engrais chimique sont également produits. Il est prévu que les usines sucrières, les associations de cultivateurs de la canne à sucre, les organismes gouvernementaux, les agronomes, et les vulgarisateurs feront usage de ce logiciel.
CANAFERT 1.0: UN SOFTWARE DE RECOMENDACIÓN DE FERTILIZANTE QUÍMICO PARA LA PRODUCCIÓN DE CAÑA DE AZÚCAR EN TAILANDIA

P. PRAMMANEE¹, A. JINTRAWET², C. LAIRUNGREUNG¹ y S. KONGTON³

¹Suphanburi Field Crops Research Center, U-Thong Suphanburi 72160 Thailand
²Chaingmai University, Chaingmai, 20000, Thailand
³Soil Survey and Classification Division, Department of Land Development Bangkok 10900

Email: pramm@access.inet.co.th

PALABRAS CLAVES: Recomendación de Fertilizante, Modelo de Simulación, Análisis del Suelo.

Resumen

El fertilizante químico responde por una parte sustancial de los precios de producción de la caña de azúcar en Tailandia, dónde la mayoría de los productores de caña no tiene el conocimiento básico con respecto al uso de fertilizantes. Un programa de computadora, CanaFert 1.0, está desarrollándose para determinar con precisión las recomendaciones, para la aplicación de N, P y K usando las propiedades de los suelos usados, para la producción de caña de azúcar a lo largo de Tailandia. El proyecto incluye: identificación del suelo de caña de azúcar usando mapas de series de suelo; estudios de campo para confirmar la identificación; determinación de requisitos de nutrientes; simulación de crecimiento de caña usando CANEGRO 3.5 para determinar el efecto de agua y nitrógeno; análisis económicos de recomendaciones de fertilizante químicas y ensayos de validación para confirmar las recomendaciones generadas por CanaFert 1.0. El software resultante permite a los usuarios identificar el sitio, apuntando una flecha en un mapa mostrado en la pantalla de la computadora. La ubicación de la hacienda, las series de suelo, las propiedades químicas del suelo, las exigencias de N-P-K, la cantidad y los métodos de aplicación de fertilizante químico también se generan. Se anticipa que las fábricas de azúcar, las asociaciones de productores de caña de azúcar, agencias gubernamentales, agrónomos, y obreros de extensión usarán este software.