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SimCorn - A Software Designed To Support Site-Specific Nutrient Management For Farmers of Small Parcels In The Tropics.

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Abstract. Farmers in developing countries sometimes receive incorrect and misleading information regarding the fertilizer inputs into food production, especially during crises or times of unusually high demand. In the early 2000's farmers of Thailand were sold fake fertilizer or advised to apply excessive amounts of fertilizers by fertilizer dealers. The problem was so pervasive that a protocol was developed to address the problem. This protocol of three steps was based on providing improved information to empower the farmers. The first step was a simplified, field identification of soils, the second was a soil test kit that farmers could use themselves, and the third, described here, was a decision-aid that brought together soil, crop, climate and fertilizer principles with local field data needed to select the correct fertilizer and to calculate the correct amounts to apply. The SimCorn software was designed to estimate fertilizer N, P, and K amounts and how to supply these nutrients using existing fertilizer materials, which seldom come in the desired ratios of N, P, and K. The N algorithm was based on the Decision Support System for Agrotechnology Transfer (DSSAT) 3.5 simulation model which has been adapted to accept soil test kit nitrate as the current N status of the field. Phosphorus requirements were predicted by the Phosphorus Decision Support System (PDSS} program. Potassium fertilizer requirements were based on a Mitscherlich-Bray equation. These algorithms were implemented in both desktop and handheld computers in both Thai and English languages. A blending algorithm was also implemented which calculates the amounts of existing N, P and K fertilizers for a blended fertilizer. This software was first implemented on a handheld platform using a Palm operating system and then subsequently implemented on a desktop computer under a Windows XP operating system. The software is used by extension officers and other interested persons.

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Keywords. Fertilizer Calculations, Soil Testing, Site-specific Nutrient Management.

Introduction

Farmers and managers of the land and crops are frequently victims of economic circumstances – they take great risk with the weather, disease and pest outbreaks, and other usually unpredictable acts of nature. The risks that occur at the marketplace are no less variable or unpredictable. Farmers are often easy targets for fraudulent advertising and misleading sales efforts. The situation in the tropics for farmers of small parcels of land in the tropics is no different and is probably more challenging than that occurring in temperate agriculture.

Site-specific nutrient management is one of many applications of the principles of Site-Specific Agriculture or sometimes called Precision Agriculture. This technology seeks to reduce mis-applications and increase the tailoring of technology to the situation and specific conditions. It is an extension of the concept of tailoring the solution to the problem. Nutrient management has been notorious for attempting to apply the 'one size fits all' concept through the use of 'blanket fertilization' strategies such as suggesting that there are crop-specific fertilizers rather than tailoring fertilizer type and amount to both the site and crop. While Site-specific nutrient management seems to have many benefits, a recent analysis shows that the practice of site-specific nutrient management and, indeed, of Precision Agriculture as a whole, has been rather slowly adopted (Friedrichsen et al., 2004). Moreover, the high technology usually associated with Precision Agriculture is largely unavailable to the farmers of small land parcels typical of the Tropics. One of the hypotheses of this work was it is possible to bring site-specific nutrient management to farmers of small parcels without the high technology requirement.

The Site-specific nutrient management technology described herein has been developed for the farmer leaders in Thailand for about 4 years. The technology we've developed has three components: 1) The field identification of soil series by farmers and farmer leaders, 2) Measuring soil pH and nutrient status by farmers and farmer leaders using a soil test kit in the field or nearby to it, and 3) Carrying out the interpretation of the measured results in light of the farmers selected crop and target yields (Attanandana et.al., 2004). The dissemination of the technology has resulted in a higher standard of living of the farmers and reduction of their indebtedness (Attanandana et al., 2005). The development of the software – SimCorn, was initiated in 2003 to speed the dissemination of the technology to the farmers. The software was introduced to International Participants at a Workshop and was well-received by 40 participants from 11 countries (Phonphoem, 2003)

The purpose of this paper and presentation are to share the experiences in implementing the agronomic information in a new medium based on tools and techniques made possible by information technology. Our hypothesis was that the organizing and structuring of this information for the decision-aid would improve the information for fertilizer recommendation to the farmer leaders and officers and vice versa. The improvement would come, we expected, from the scrutiny given the information while preparing it for delivery to the users as well as for farmer reaction and discussion of the information (the diagnosis and recommendation). We were also interested in taking the knowledge to the locus of decision-making – in other words getting the right information to the right person at the right time for an optimal decision. To this end, we thought that being able to take the decision-aid to the field had the following advantages:

- The decision-aid would provide the information to the person in most need of the information and for whom the information would be the most valuable.
- We would like the decision-aid to "empower" the farmer or manager with this knowledge so that it would improve the efficiency and profitability of the enterprise
- Certain types of information is only present in field situations and such information would help make the decision-aid prediction more realistic and relevant to the situation

Materials and Methods

Hardware and software for program development

- A Palm computer with the Palm OS 3.1 or later, such as the Palm model M100
- A microcomputer running Windows OS with Windows 98 or later
- A computer palm data transfer kit (Hotsync kit)
- A Palm OS Emulator Program
- A Thai language pack for Palm, such as ThaiHack

Overall program structure

The program structure consists of a central database separated into a small tables. The User interface, Soil Series and Corn Data, and Fertilizer Recommendation Sections retrieve the information from the central database as shown in Fig. 1(Attanandana et al., 2004). The program consists of 3 main sections

Section A: Soil Series and corn data section

There were several major tables in the database: 1) A soil property table and 2) A table with the N recommendations and several user information tables including a soil series property data table, and a table of fertilizer materials. The function of the soil table was to support the field identification of the soil series. A form was presented to the user to gather the following properties (all observable in the field):

- Soil color (four choices: black to dark brown, brown to yellowish brown, red to reddish brown, and light gray to pinkish gray)
- Soil texture(three choices: loamy sand or sand; loam, clay loam or sandy clay loam, silty clay loam; clay, gravelly clay)
- Coarse fragments (three choices: limestone concretions, laterite, shale fragments)
- Soil pH (three ranges, estimated with the soil test kit indicator solutions: 4.5-5.5, 5.5-6.5, 6.5-8.0)
- Depth of soil, to rock or root limiting zone(three choices: shallow, moderately deep, deep)

The above information can be selected in a drop-down menu and a sorting algorithm selects the soil series that matches these properties. These five, simple field observations are criteria sufficient to uniquely identify 324 soil series – more than sufficient for the current 38 series of the Thailand maize belt (Boonsompopphan, 2006). The selected soil series is stored in Table 1 together with the indicated province. In the field manual, a color photograph of the soil profile provided visual confirmation of the selected soil series. In addition a summary table was provided that gave summary properties of the soil series should the software user have questions. This data table can be found in SoilAttrDatabase.pdb.

Table 1. SimCorn table containing the Soil Series and DSSAT N recommendation information (with an example record)

Primary key of the table		Result of the N analysis using the Soil Test Kit		
Soil Series	Province	Very Low	Low	Medium
		N fertilizer recommendations (kg N rai^{-1})		
Lb(Lop Buri)	Lop Buri	10	6	4

This table expands quickly – with 38 series and four provinces of the maize belt, but permits very rapid access to the results of the N simulation.

Section B: Fertilizer recommendation section

A second form captures the results of the soil test kit analysis of the soil N, P, and K contents (very low, low, medium, and high). These categories have been calibrated to numerical values which are substituted into the recommendation equations. The information from the soil test kit information form is added to that of the series and province to complete a major table in SimCorn (Table 1).

Nitrogen (N) recommendations were developed offline using the DSSAT maize software with weather data for the province and using the soil series data that was on file at the Department of Land Development (courtesy of T. Vearasilp) thus evaluating the N fertilizer requirement for all levels of soil test kit N for each combination of soil series and province (Table 1).

Fertilizer recommendations for P and K were based on the PDSS software (Yost et al., 1992, and a Mitscherlich Bray equation (Yost and Attanandana, 2006). The data requirements for calculating the P and K requirements were much less than that required for the N and thus the site-specific recommendations could be generated on-site by the modest cpu of a handheld computer. Once the specific requirements of nutrients were generated, an additional routine took the available N, P, and K fertilizer materials and developed the most economical blend to match the specific requirement for N, P, and K. Since the P containing fertilizers were the most expensive, the algorithm first selected the amount of N-P fertilizer (such as 18-46 or 16-20-0) to meet the P requirement and then added the proper amounts of urea or KCl needed to meet the N and K requirement, respectively. This additional step also indicated how much of each fertilizer material was needed to make the blend.

After the software has calculated the amount of nutrients (N, P_2O_5, and K_2O) that are suitable for the particular field, it provides fertilizer details for the basal dressing and top dressing. It also provides the bulk blending information in case the recommended fertilizer grade cannot be found in the market. The databases used in this section are SoilAttrDatabase.pdb, PlantDayDB.pdb, LB1DB.pdb, NR1DB.pdb, NS1DB.pdb, PB1.pdb, ProductDB.pdb and FerCalDB.pdb.

Section C: Program operation help section

This section provides helps for using the program (Figure 1). It also contains the researchers and program development team information

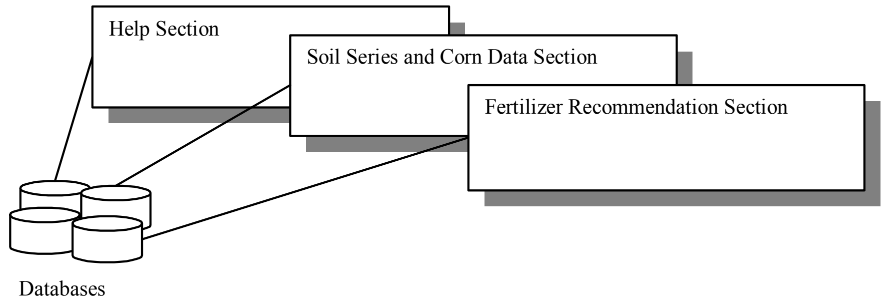

Figure 1. Program structure.

Structure of the software

The C language (CodeWarrior software) was used in the development of SimCorn for handheld computers. All tables and forms were hard-coded into the software, in part, to ensure maximum speed. If the development were to be part of a long-term maintenance program, it might have been useful to build additional interface structures and database functions into the software. There was no clear demarcation between the data and the algorithms, which made revision and updating somewhat more difficult. On the other hand, this approach was sure to be one of the most efficient and rapid. Since this was our first implementation of a software for the handheld, there was considerable uncertainty regarding the capacity for the necessary calculations. There were challenges in fitting the necessary information into the small format screen while ensuring that the font that was sufficiently visible. One advantage of the handheld, however, was the ease in switching from portrait to landscape mode by the simple flick of the wrist.

For the desktop version, Visual Basic was used as the development language – it offered options for a relational database that would increase the extensibility of the software as well as permit adapting to different regions with different database entries. The much larger memory capacity of the desktop also permitted a dramatically improved interface and help screens for users.

Results and Discussion

As indicated above the SimCorn software was part of a larger effort to enable and empower farmers by providing them with site-specific nutrient management information on site. We consider the software was very successful in meeting this objective and have summarized the procedures and other aspects of the entire participatory approach to site-specific nutrient management elsewhere (Attanandana and Yost, 2003). The initial two parts of the overall participatory site-specific nutrient management were discussed in the Materials and Methods and include the *soil series identification* in the field and the *soil test kit*

The soil test kit. A soil test kit was previously invented and adapted for use in the field. This kit provided the critical site-specific information such as the analytical results for N, P, and K from soils collected in the field. This information served two purposes in the overall approach 1) It permitted a diagnosis of whether the current soil nutrient status was sufficient and 2) It permitted a quantitative estimate of status of N, P, and K, that when combined with the soil series information and knowledge of the maize cultivar, permitted a prediction of the optimal time of planting and the appropriate amounts of N, P, and K fertilizer to meet target yield levels.

The SimCorn software was then used to interpret the above collected data and information and to carry out a quantitative calculation of the amounts and grades of fertilizers needed to meet the calculated requirements (Figure 2).

The results of application of the SimCorn technology have been remarkable. In a survey of 338 farmers the following results were obtained (Attanandana et.al., 2005). Not only were yields higher in most cases, but generally the amounts of N and P recommended by the software were less in some provinces and more in other provinces compared to the current application rates. The software recommended adding more potassium (K) than was the current practice, however. This observation has led to further research on assessing the appropriate amounts of K fertilizer

A marked increase in yield of site-specific nutrient management compared to the farmers' practice in 2003 was also observed (Attanandana et.al., 2006a). The data in 2004 showed clearly the benefit of site-specific nutrient management technology (Attanandana et al., 2006a).

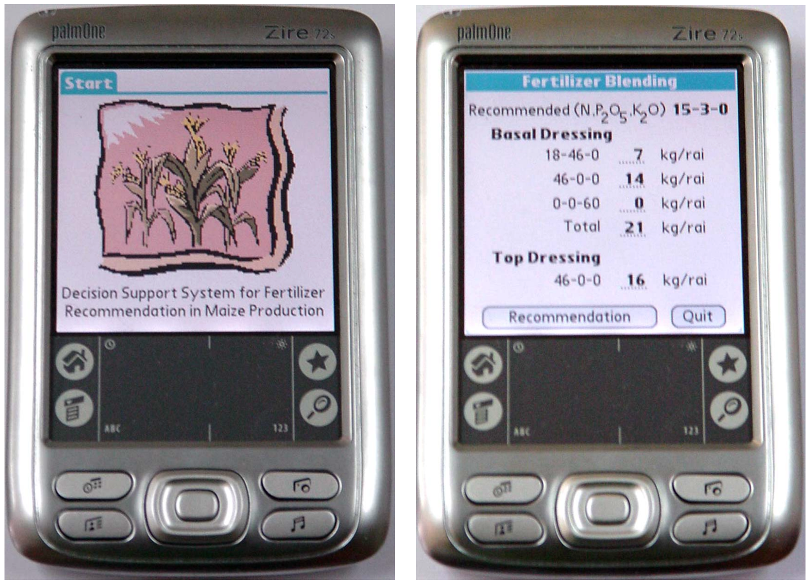

Figure 2. Screens of the SimCorn software initial screen (left) and final recommendation (right).

The data in 2005 again showed the benefits of site-specific nutrient management especially at the time of high price of petroleum in 2005. We found that farmers who used site-specific nutrient management had a reduction in profit, about one-half that of the year 2004, but the farmers who did not use site-specific nutrient management had a loss (Attanandana et., 2006b).

When the profit and cost of production ($/T) in site-specific nutrient management fields were compared with no site-specific nutrient management fields, it was seen that the cost of production was low with high profit with the site-specific nutrient management but it was opposite in the no site-specific nutrient management fields (Figure 3).

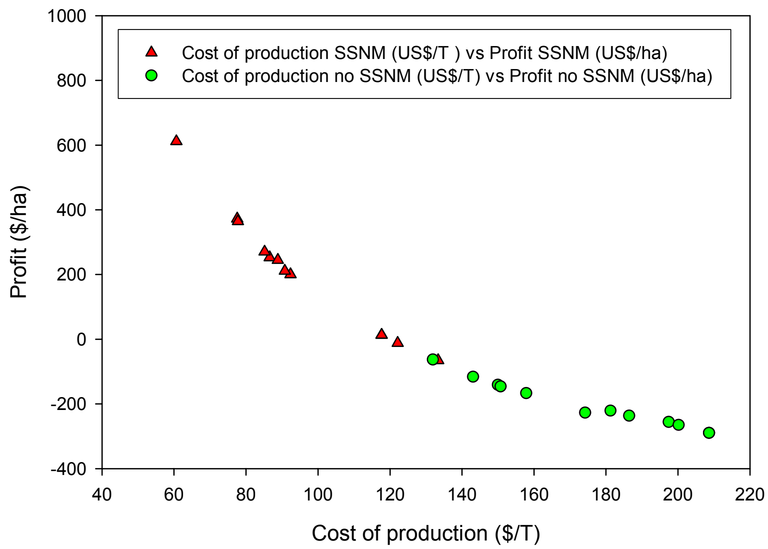

Figure 3. Profit and cost of production in SSNM and no SSNM plots

The SimCorn software was developed on the handheld and desktop and was distributed to the extension officers and interested persons. The software on the desktop has been more useful because most of the extension officers have occasional access to a computer while not so many people have a handheld computer. The handheld computer can be used in the remote locations and it is more handy. In the near future when the handheld is becoming more popular, the software on the handheld might be more useful. The disadvantage of handheld was the limited memory for confirmatory photographs, which is no longer a limitation. We also like the opportunity provided by the handheld to record information in the field, although extensive entry of text could become tedious.

Future development

We are considering putting the SimCorn on the web so that it can be used directly on the website. This will make the software available to by many people. We would like to develop an economic analysis modulet to calculate cost of production and profitability. For example, the farmers can calculate the cost of fertilizer use and the price of crop at that time and then decide to use the amount of fertilizer recommended or reduce the amount of fertilizer if the benefit / cost ratio is too low. The economic analysis would thus be another benefit and added information to empower the farmer with this analysis to assist in making better management decisions.

Conclusions

We found that the many site-specific details of a fertilizer recommendation could easily be accommodated in a handheld computer and that, by pre-processing, the handheld could retrieve results from a detailed computer simulation and prepare quantitative advice to growers and farmers. This could be done in the field, or close by it resulting in certainly far more rapid response and availability of the information. We suggest that the quality of the information and its timeliness make this technology option very attractive We believe that in this way, site-specific information can be brought to the farmers of small tracts of land and will substantially improve their management.

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