ALABAMA CROPMAN: A USER FRIENDLY INTERFACE FOR CROP PRODUCTION SIMULATIONS

H.A. Torbert, T.J. Gerik, W.L. Harman, J.R. Williams, and E. Steglich
USDA-ARS National Soil Dynamics Laboratory
411 S. Donahue Dr., Auburn, AL 36832-5806
atorbert@ars.usda.gov

T.J. Gerik, W.L. Harman, J.R. Williams, and E. Steglich
Blackland Research and Extension Center Texas A&M University
720 E. Blackland RdTemple, Texas 76502

ABSTRACT

The impact of cropping and tillage systems on agriculture production is very complicated, making it very difficult to predict the economic and environmental consequences of changes in agronomic practices. To better understand the potential consequences of agriculture practices, a user-friendly computer simulation model, "Alabama CroPMan", has been developed to be used under Alabama conditions. To validate the model for Alabama conditions, a data base of cotton, corn, and peanut crop yields (from 1997 - 2001) was collected using the variety testing data from three Alabama Agriculture Experiment Stations, representing southern, central, and northern portions of the state (Wiregrass, Prattville, and Tennessee Valley). At each of these locations, the soil type, historical weather data during that time period, and agronomic cultural practices where the study was conducted were utilized for the model simulations. At the Wiregrass Experiment Station, simulation of peanuts was also conducted, using the variety test yields for early, middle, and late maturing varieties. Results from the validation study indicated that the model performed very well in predicting the actual measured yields for corn, cotton, and peanut. The overall objective for the development of this model is to have it be used as a tool to promote the adoption of best management practices for farm production in the Southeast. The model was found to be very useful to derive predictions of not only crop yields, but also the economic and environmental consequence of agriculture production.

INTRODUCTION

The influence of cropping and tillage systems systems on agriculture production is complicated by the diverse and distinctive soil and weather conditions found in any given location and year. While years of agriculture research have resulted in a greater understanding of agronomic processes, the complexity of these systems and the variability resulting from varying soil and weather conditions makes it difficult to predict the economic and environmental consequences of changes in agronomic practices. In order to better understand these complex systems, scientists have developed computer simulation tools that track the varying environmental conditions and agronomic forces that impact agriculture production. One such model is the Crop Production and Management Model (CroPMan).

CroPMan was developed by scientists at the Blackland Research and Extension Center, Texas A&M University, to help agricultural practitioners optimize crop production, to identify limitations to crop yield, and to identify best management practices that minimize the impact of agriculture on soil erosion and water quality. It is a windows-based application of the Environmental/Policy Integrated Climate model (EPIC) (formerly Erosion-Productivity Impact

Calculator) which was originally developed by USDA-Agriculture Research Service (USDA-ARS) to simulate the interaction of natural resources and crop management practices (Williams, 1995). While the EPIC model has been successfully used to simulate agriculture production in Alabama (Mullins and Hajek, 1997), it requires extensive database development for utilization. The purpose of the CroPMan model was to extend the usefulness of the EPIC model by developing a decision aid easier to use and to set up for analyses of complex farming practices. This manuscript will describe the effort to expand the CroPMan model to the conditions found in Alabama, by developing the management options and appropriate databases to make the model functional under Alabama and other southeastern US regional conditions.

MATERIALS AND METHODS

Alabama CroPMan

The National Soil Dynamics Laboratory, in cooperation with scientists at the Texas A&M Blackland Research and Extension Center, has developed "Alabama CroPMan" that is applicable to the conditions for the state of Alabama. The engine for the model is EPIC, developed by the USDA-ARS and utilizes databases developed by the USDA-National Resource Conservation Service (USDA-NRCS). The major components in EPIC are weather, hydrology, erosion-sedimentation, nutrient cycling, pesticide fate, plant growth, soil temperature, tillage, economics, and plant environment control (Williams, 1989). CroPMan is a user-friendly interface that will allow scientists, farmers, and farm advisors to utilize the EPIC model to examine the environmental and economic consequence of crop production decisions (Gerik et al., 2003).

The model is to be used as a tool to promote the adoption of best management practices for farming in Alabama by allowing for the assessments of agronomic practices. For example, the model will allow strategic assessments to: 1) identify best management practices for site-specific circumstances to minimize cropping impact on soil erosion, water quality, and runoff; 2) identify production constraints and alternative practices to maximize yield, profit, and production efficiency; and 3) determine fertility/nutrient requirements and nutrient and pesticide fate. CroPMan also extends EPIC's capabilities with "Projected Runs", which allows for the stopping of the model at any point in time (usually the current time), providing for updates to selected soils, crops, and management practices, and projecting between 40 and 100 weather scenarios through the remaining growing season to estimate probability distributions of outcomes. This will allow the model to perform real-time analyses to assist in decisions such as: late planting, replant decisions, fertilizer optimization, estimates of yield and profit, and soil/nutrients/pesticides in runoff.

EPIC is a continuous, daily time step simulation model that can be used to determine the effect of management strategies on agricultural production and soil and water resources. The drainage area considered by EPIC is generally a field-sized area of about 250 acres. Weather, soils, and management systems for the entire field area are assumed to be homogeneous. A method for estimating costs of operating farm machinery has been added to CroPMan as a subroutine. Costs were taken from the USDA-NRCS CARE budget generator. The subroutine calculates the operation and depreciation costs per area covered for over 500 pieces of equipment including the tractor(s) used and calculates costs for all operations scheduled at the start of the simulation. The economics of each analysis are calculated according to the computing standards of the American Agricultural Economics Association for variable costs, depreciation, and profits.

The database provided with the Alabama CroPMan program includes actual soils and weather stations from across the state of Alabama (Fig. 1). The 48 different weather stations contain 40 years of historical weather data from that location. The soils database is provided for each county in Alabama and soil characteristics are populated from the Soils-5 database, which was created and is maintained by the USDA-NRCS.

To develop the Alabama CroPMan, "typical" crop operation budgets were developed for the major crops in Alabama, including cotton (*Gossypium hirsutum* L.), peanut (*Arachis hypogaea* L.), soybean (*Glycine max* L.), corn (*Zea mays* L.), grain sorghum (*Sorghum bicolor* L.), and wheat (*Triitcum aestivum* L.). For each of these crops, a typical operation budget was developed for a conventional tillage, a reduced tillage, and a no tillage system. Also, several cropping rotation systems common to Alabama were included. These budgets included a complete listing and timing of agronomic cultural practices needed for that production system and included practices such as fertilization, planting dates, land preparation (such as plowing equipment and frequency), pesticide application, irrigation, and harvesting. Figure 2b shows an example of the budget developed for conventional tillage corn production under dry-land conditions. Input for developing these budgets were collected from various sources such as the Budgets for Major Row Crops in Alabama (Crews et. al., 2001) and Southern Agriculture Digest (Gonitzke et al., 2003). All of the cropping systems can be altered to provide the specific conditions of interest to the user. More specific details as to the operation and specifics of the model simulation can be found in the CroPMan Users Manual (Gerik et al., 2003).

Alabama Validation

To validate the model for Alabama conditions, a database of crop yields was acquired and used from the variety testing studies, which are collected each year from across the state of Alabama by the Alabama Agriculture Experiment Stations. Three Alabama Agriculture Experiment Stations were chosen to represent the southern, central, and northern portions of the state (Fig. 1). In south Alabama, the Wiregrass Research and Extension Center in Headland, Henry County, AL was chosen. In central Alabama, the Prattville Agricultural Research Unit in Prattville, Autauga County, AL was chosen. In north Alabama, the Tennessee Valley Research and Extension Center, in Belle Mina, Limestone County, AL was chosen. At each of these locations, the variety testing data were collected for corn and cotton for a five-year period, from 1997 through 2001. At each of these locations, the actual soil type where the study was conducted and the historical weather data collected at the site during that time period was utilized for the model simulation. Also, the actual agronomic cultural practices used in the variety test experiments at each site was used in the simulation, including the soil fertility and land preparation system. The average for all of the varieties tested each year was used as a surrogate for yield potential for those conditions each year. At the Wiregrass Experiment Station, simulation of peanut was also conducted, using the variety test yields for early, middle, and late maturing varieties.

RESULTS AND DISCUSSION

Initial evaluation of the Alabama CroPMan model indicates that it could be a very successful adaptation, which provides a user-friendly interface for the EPIC model. At the initial setup window (Fig 2a), the user selects the Alabama County of interest, which then allows for all of the soils that have been mapped in that county to be selected from drop down windows. In the setup window there is a list of the 48 available weather stations from across the state, which can be selected to provide 40 years of historical weather data. Also included is a drop down window, which includes the list of cropping systems, which will provide the "typical" cropping systems for the state of Alabama.

After the initial specifications of interest are selected, the model can be run to provide output across the years of simulation. The output includes variables such as crop yield and profit (Fig. 2c and d). The output includes stresses that impacted the production of the crop, including such things as drought, excess water, temperature, N, and P. The model also provides output for losses from the cropping systems, such as soil, N, and P losses in runoff. This output is provided in clear graphical form (Fig. 2), which can be seen by selecting the variable of interest.

In addition to the standard model runs, the Alabama CroPMan also provides comparison runs (Fig. 2a). In the comparison runs, the output from two different standard runs can be compared. With this tool, the potential consequence of production decisions can be observed in graphical form. For example, Figure 2e demonstrates the differences in potential yields between conservation tillage and a no tillage cropping systems. The model can also be used to provide projected runs. In this mode, the model is run as a standard run with actual weather data to a designated point. Following this, the model can be restarted to provide 40 to 100 years of projected weather conditions that would be potentially found within the area of the selected weather station (Fig. 2f). In this manner, the potential risk of a specified management choice can be ascertained, and by subsequent runs, the potential differences in management choices (such as replanting) can be determined.

Results from the validation of the CroPMan model indicated that the model performed very well to predict the actual measured yields for corn, cotton, and peanuts (Figs. 3, 4, and 5). The validation data for corn yield is shown in Figure 3. A wide distribution in corn yields was observed across the state during this 5-year period due to both the wide variability in the soils used and the variable weather conditions, which occurred during the study period. This provided a wide scale of conditions under which the model validation was conducted. The model did a good job of predicting the observed corn yields, as can be observed in Figure 3. The figure presents the regression analysis of the predicted vs. measured yields. The resulting regression line falls almost exactly on the 1:1 line of the graph and has a very good R^2 value (0.7157), indicating that the model performed well with the variability of the measure yields.

The validation data for cotton lint yield is shown in Figure 4. With cotton lint, the distribution of yields was also very great across the state during the 5-year period, and provided a very good data set for validation purposes. The model did an adequate job of predicting the measured yields (Fig. 4). Again in Figure 4, the regression line falls almost exactly on the 1:1 line of the graph for the regression of predicted vs. measured yields. In the case of cotton lint, the variability of the model to predict yields were greater than was observed with corn, as indicated by a R^2 value of 0.3698. This was likely due to the nature of cotton production being much more variable and subject to potential limitation from disease and insect damage than corn, which the model does not simulate. Nevertheless, the result of this validation exercise indicates that the model does an adequate job of predicting the measured cotton lint yields.

The validation data for peanut yield is shown in Figure 5. With peanut, the yield distribution was relatively small compared to the corn and cotton, but was sufficient to provide an adequate data set for validation (Fig. 5). In Figure 5, as was observed with the corn and cotton, the regression line for predicted vs. measured peanut yield falls almost exactly on the 1:1 line of the graph. In the case of peanut, the variability explained by the model, as indicated by the R^2 value of 0.5915, was excellent. As with the corn and cotton, the results of this validation exercise indicates that the model does an adequate job of predicting the measured peanut yields.

SUMMARY

The initial evaluation of the Alabama CroPMan model indicates that the model performs well for its designed purpose. To validate the model for Alabama conditions, a database of cotton, corn and peanut crop yields was collected using the crop variety testing data from across the state. Data was collected from the Wiregrass Experiment Station in south Alabama, the Prattville Experiment Station in central Alabama, and the Tennessee Valley Experiment Stations in northern Alabama. Results from the validation study indicated that the model performed very well to predict the actual measured yields for corn, cotton, and peanut. The Alabama CroPMan model was found to be very user friendly and provide a wide variety of agronomic, economic, and environmental information regarding agricultural practices and production. The Alabama CroPMan model has a very good potential to be used as a tool to increase the understanding of agriculture and to promote the adoption of best management farming practices in the Southeast.

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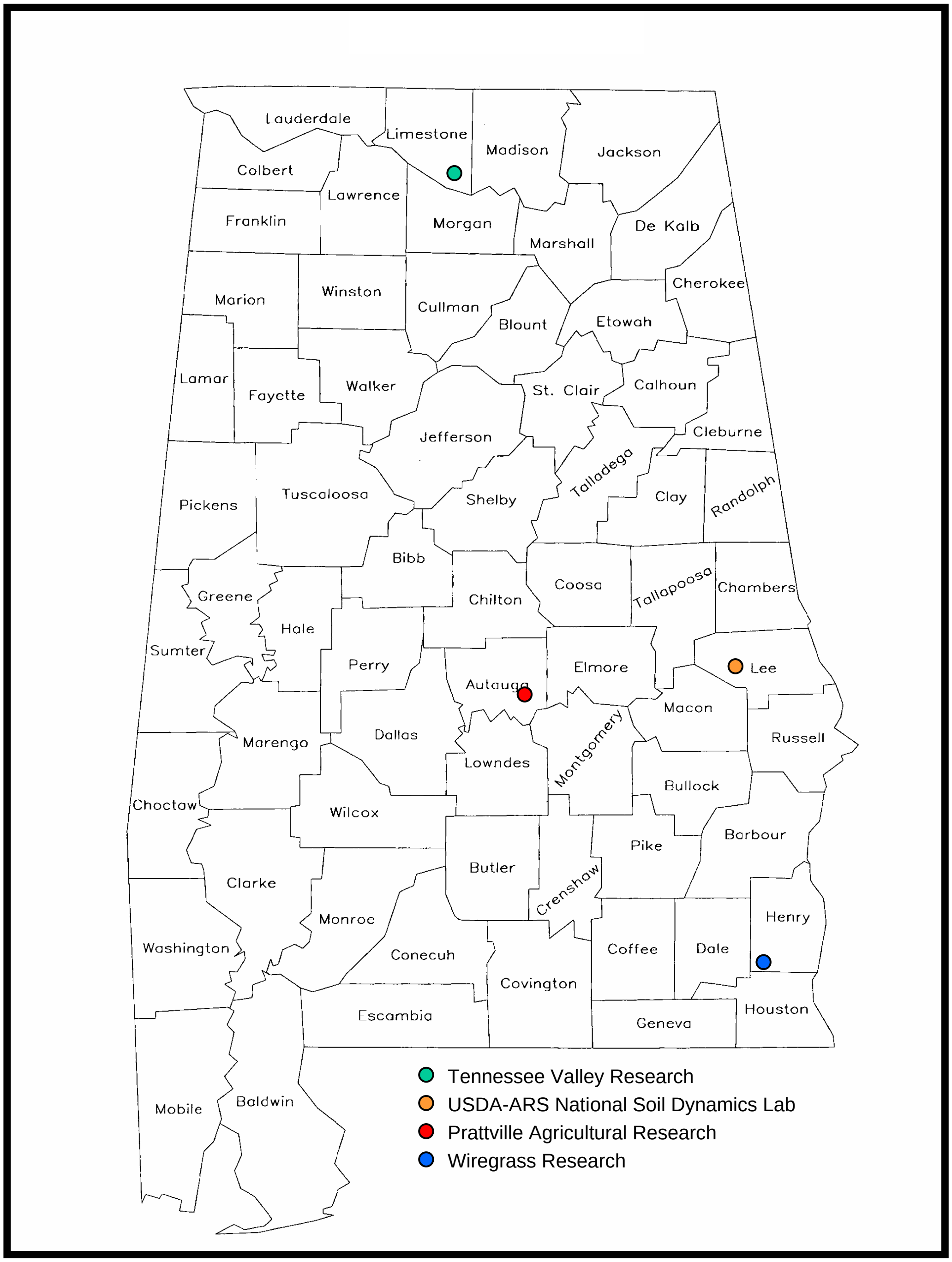

Fig. 1. Map of Alabama counties and the location of Alabama Agriculture Experiment Stations where validation research was conducted.

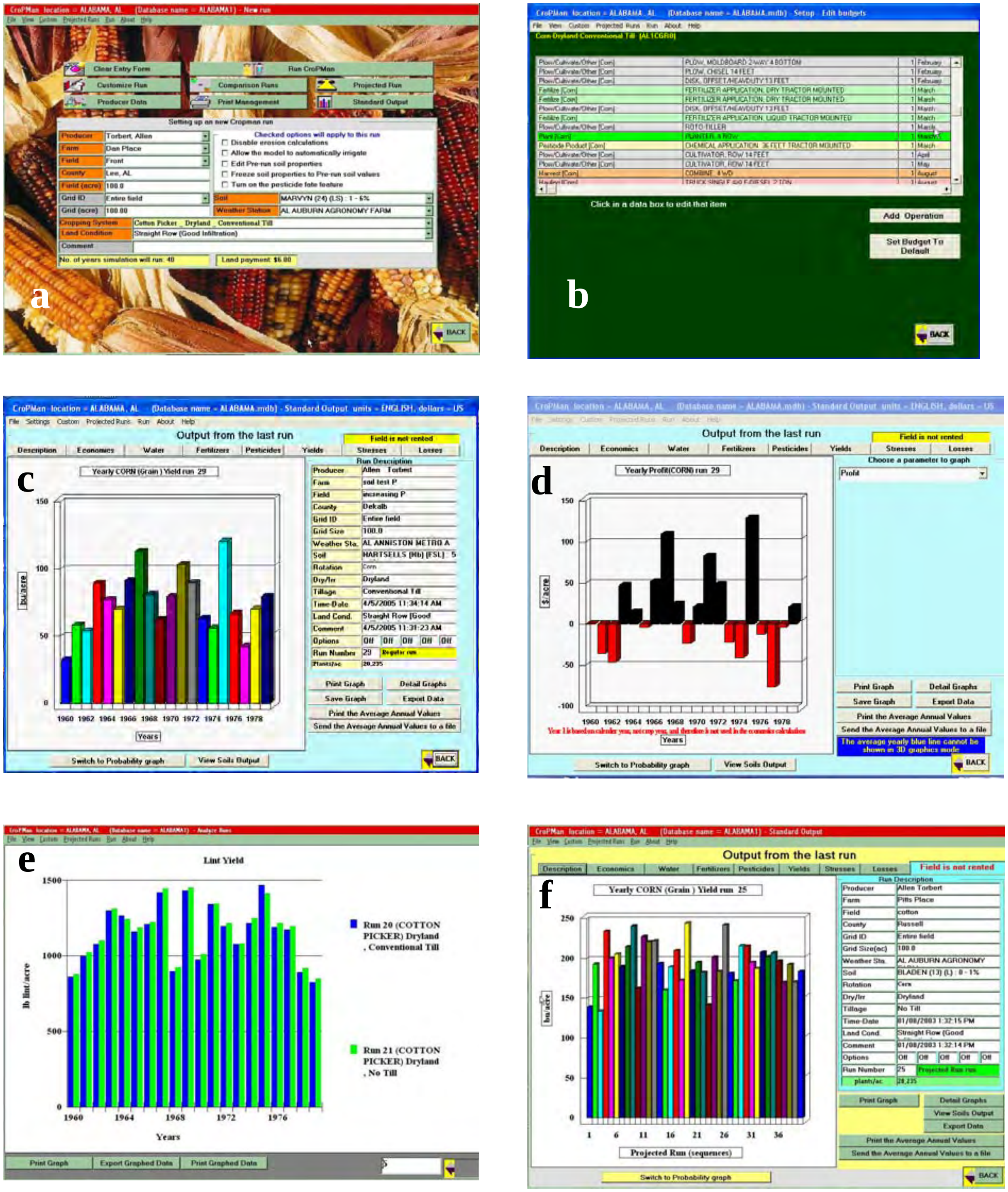

Fig. 2. Alabama CroPMan views: a) standard run setup, b) cultural practice setup c) output yield, d) output profit, e) output comparison yield f) output projected yield.

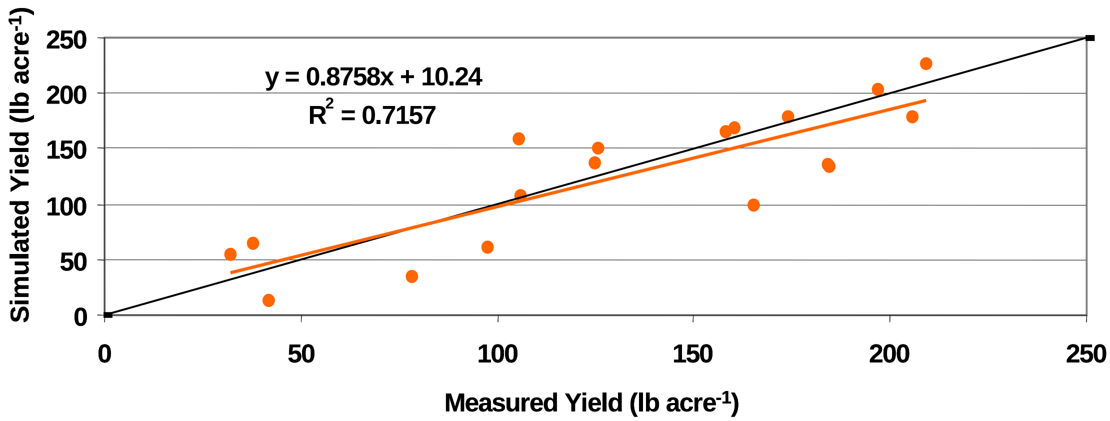

Fig. 3. Validation of corn yield in Alabama, simulated vs. measured corn yield.

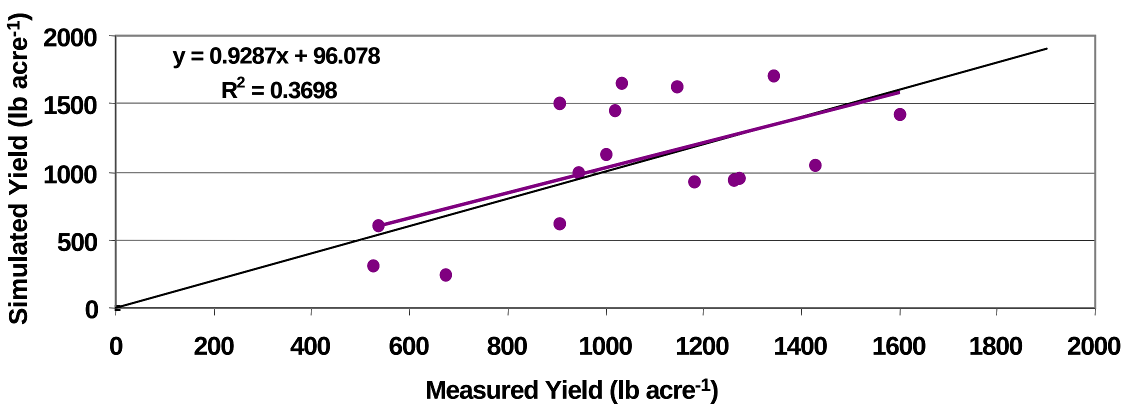

Fig. 4. Validation of seed cotton picker yield in Alabama, simulated vs. measured seed cotton yield.

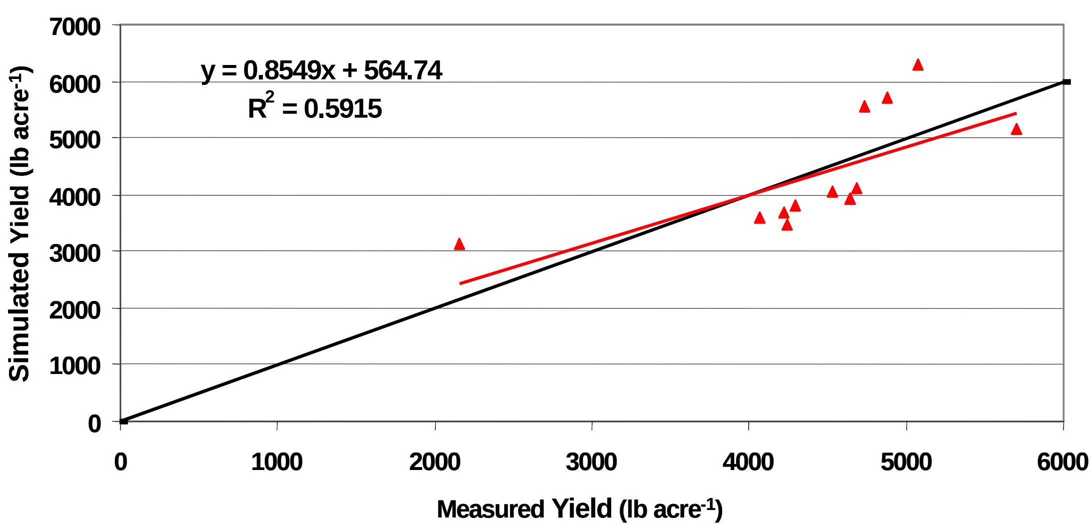

Fig. 5. Validation of peanut yield in Alabama, simulated vs. measured peanut yield.