Development of a peanut irrigation management decision aid using climate-based information

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Abstract

Water demand for irrigation in the Southeast is expected to increase in the future. There is a need to combine climate information and risk analysis for peanut irrigation in the southeastern US. This paper describes a peanut irrigation decision support system which was developed to assist growers and to provide information on the levels of profitability of peanut production with and without irrigation under different climate forecasts. The system provides probability distributions of the seasonal cost to irrigate peanuts and amount of water required. Yields were simulated for both irrigated and non-irrigated peanuts using the CSM-CROPGRO-Peanut model. Results of a case study were presented for the Georgia Green variety grown in Miller County, Georgia. The probability of obtaining a high net return under irrigated conditions increased when planting dates were delayed for El Niño years. Dryland peanut production was profitable in a La Niña year if peanuts were planted between mid-April and early May. The prototype irrigation decision support system will be deployed as a web-based tool on the AgClimate web site (www.AgClimate.org) after additional testing and evaluation.

Introduction

El Niño refers to the oceanic component of the El Niño-Southern Oscillation (ENSO) system and is characterized by a large-scale weakening of the trade winds and warming of the surface layers in the eastern and central equatorial Pacific Ocean (NOAA, 2001). El

Niño events occur irregularly at intervals of 2 to 7 years, although the average is about once every 3 to 4 years. The southeastern United States is one of the regions affected by ENSO events (Peters et al., 2003). During an El Niño event the winter in the Southeast is marked by above normal precipitation while summers are typically dry (Green et al., 1997). Crop yields in the southeastern United States are impacted by ENSO and are different, depending on the ENSO phase (Adams et al., 1996; Hansen et al., 1998, 2001).

Peanut is a major crop grown under rainfed and irrigated conditions in the Southeast. From 1997 to 2002, the total peanut farm acreage under irrigation in the region has increased (NASS, 2004). Irrigation systems provide farmers with an option to provide supplemental water to crops during dry conditions and to mitigate some of the effects of temporal rainfall variability in the region. Despite the prospect of higher yields due to irrigation, a grower always faces the question of whether or not to invest in an irrigation system and to install it in his/her field. It is possible that the expense of owning and operating an irrigation system outweighs income benefits when calculated over several years (Martin et al., 1996).

Studies have shown the potential benefits and needs of climate forecasts for the main agricultural commodities in the southeastern US (Hildebrand et al., 1999; Breuer et al. 2003). Available climate information can be used by growers to assess different scenarios and alternatives for different agricultural activities; and there is a need to combine climate information and risk analysis for peanut irrigation especially for growers in the southeastern US.

This paper presents a prototype peanut irrigation decision support system based on long-term climate information. We also present a case study for Miller County, Georgia, and the effect of irrigation, planting dates, and climate forecasts on the level of profitability on peanut production.

Climate-based Decision Support Systems

AgClimate (www.agclimate.org) is an online climate information delivery system developed by the Southeast Climate Consortium (SECC). It encompasses an interactive web site with climate, agriculture, and forestry information that allows users to assess resource management options with respect to their probable outcomes based on forecasted climate conditions. The SECC comprises six member institutions namely: Auburn University, Florida State University, University of Alabama-Huntsville, University of Florida, University of Georgia and University of Miami. Its mission is to use advances in climate sciences, including improved capabilities to forecast seasonal climate, to provide scientifically sound information and decision support tools for agriculture, forestry, and water resources management in the southeastern USA.

Agclimate consists of a web-based decision support system (DSS) in which information and dynamic applications or tools are embedded (Fraisse et al., 2005). Some of the web-based applications that have been implemented so far include a climate risk tool and a yield risk tool for peanut, tomato, and potato. One of the activities of the SECC is to develop prototypes of decision support tools relevant to agricultural and natural resource management. Development of prototypes allow SECC researchers and extension specialists to evaluate and refine the products based on stakeholder input and suggestions prior to final implementation as a web-based tool on the Agclimate web site. One of the tools that was recently developed is the Peanut Irrigation Decision Support System (PIDSS).

Peanut Irrigation Decision Support System

The PIDSS was developed to assist peanut producers in evaluating their long-term economic risks associated with strategic decisions related to irrigation. The program was developed using Microsoft™ VisualBasic, and it links to an Access database. The program requires output from a crop simulation model that is used to calculate the probabilities of several seasonal economic and crop management variables, namely: net return, irrigation cost, irrigation water, and rainfed/irrigated yield ratio (Fig. 1).

The system has two forms or windows. The first window shows the main interface (Fig. 2) and the second window is for the detailed cost structure (Fig. 3). Using the main window, users can select the peanut variety, location, and soil type using the dropdown menus located on the left side. The right side of the main interface shows the probability table and chart. The table has three tabs, namely: probability, probability of exceedance, and average, from which users can select. The system provides users with a quick and interactive way of analyzing the effect of different ENSO phases on the probability distribution and probability of exceedance for different locations and soil types. Users can also highlight selected columns, i.e. planting dates, and the system will automatically generate a probability histogram for the selected planting date(s).

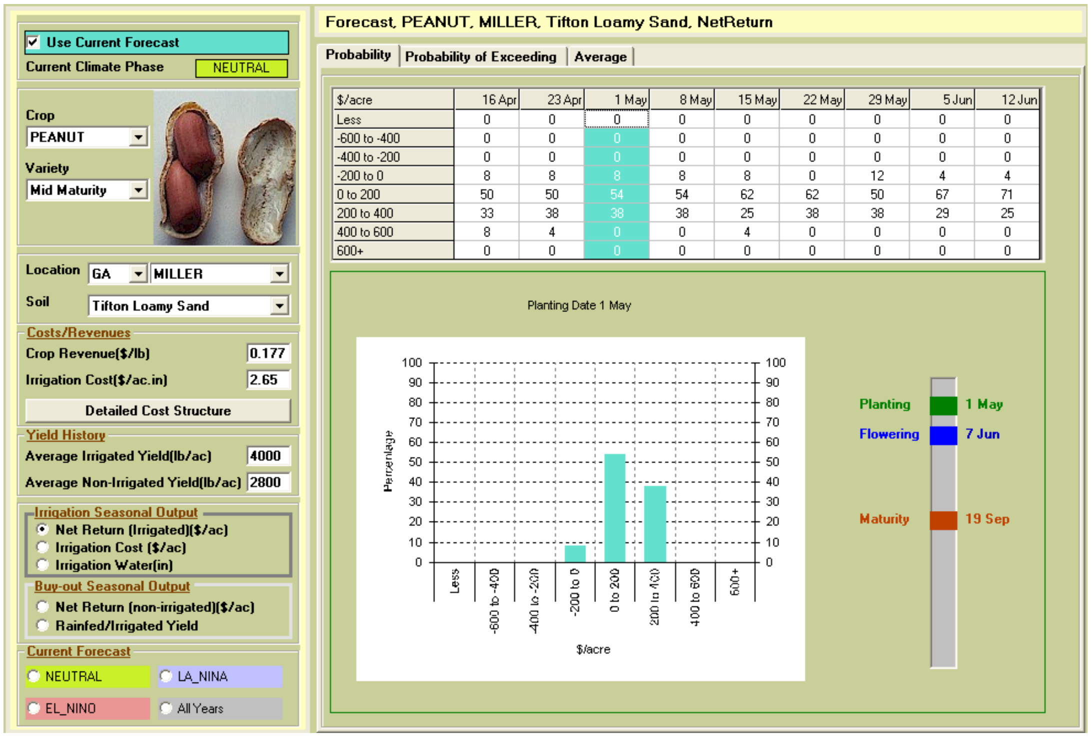

Figure 1. The Peanut Irrigation Decision Support System interface showing the probability table and chart of net return (US$/ac) of irrigated peanut production in Miller County, GA.

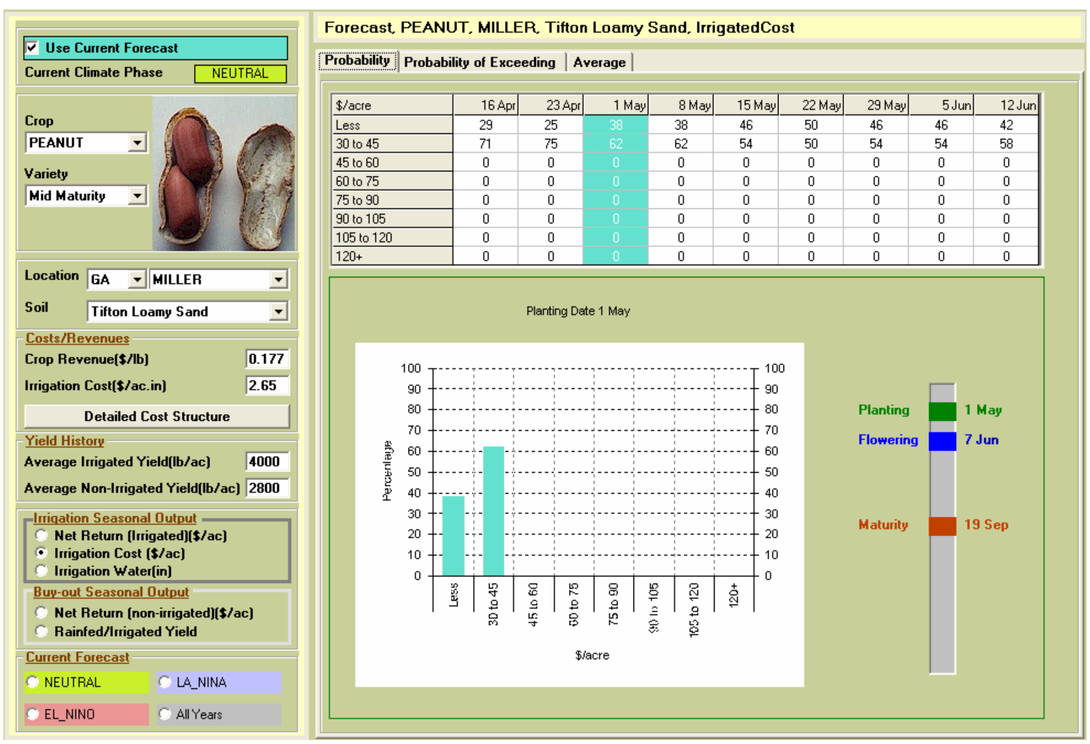

Figure 2. Probability table and chart of estimated irrigation cost (US$/ac) of peanut production in Miller County, GA.

Variable Cost

	Units	Quantity	Price/Unit	Total Cost per Acre
SEED	lb	115.00	0.55	63.25
LIME	ton	0.50	48.00	24.00
INOCULANT	lb	6.00	1.00	6.00
+ FERTILIZER				13.45
HERBICIDES	ac	1.00	40.00	40.00
INSECTICIDES	ac	1.00	32.00	32.00
FUNGICIDES	ac	1.00	85.00	85.00
NEMATICIDES	ac	0.00	60.00	0.00
+ MACHINERY PREHARVEST				30.89
+ MACHINERY HARVEST				33.48
LABOR	hour	5.52	9.25	51.06
CROP INSURANCE	ac	1.00	15.00	15.00
INTEREST ON OP CAP	$	394.13	0.06	11.82
CLEANING	ton	0.58	10.00	5.80
DRYING	ton	1.17	15.00	17.55
GPC GPPA	ton	1.85	3.00	5.55
NPB	$	0.01	621.25	6.21
TOTAL VARIABLE COST				441.06 $

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Fixed Cost

	Units	Quantity	Price/Unit	Total Cost per Acre
PREHARVEST MACHINERY	ac	1.00	52.70	52.70
HARVEST MACHINERY	ac	1.00	96.50	96.50
IRRIGATION	ac	1.00	70.00	70.00
GENERAL OVERHEAD	$	441.06	0.05	22.05
MANAGEMENT	$	441.06	0.05	22.05
TOTAL FIXED COST				263.3 $

Total Cost per Acre Excluding Land: 704.36 $

Figure 3. PIDSS cost structure section which allows the user to customize prices and quantities according to local conditions.

The other window shows the detailed cost structure which provides the different components of the variable and fixed costs used in the enterprise cost analysis for irrigated peanuts (Smith et al., 2004). This section allows the user to customize prices and quantities according to his/her local conditions. The program also allows users to export the values to a spreadsheet. Changes made in the cost structure are automatically reflected in the probability tables and charts of net returns and irrigation cost.

In addition to net returns and irrigation cost, users can examine the distribution of total irrigation water requirements for a particular planting date under different ENSO phases (Figure 4).

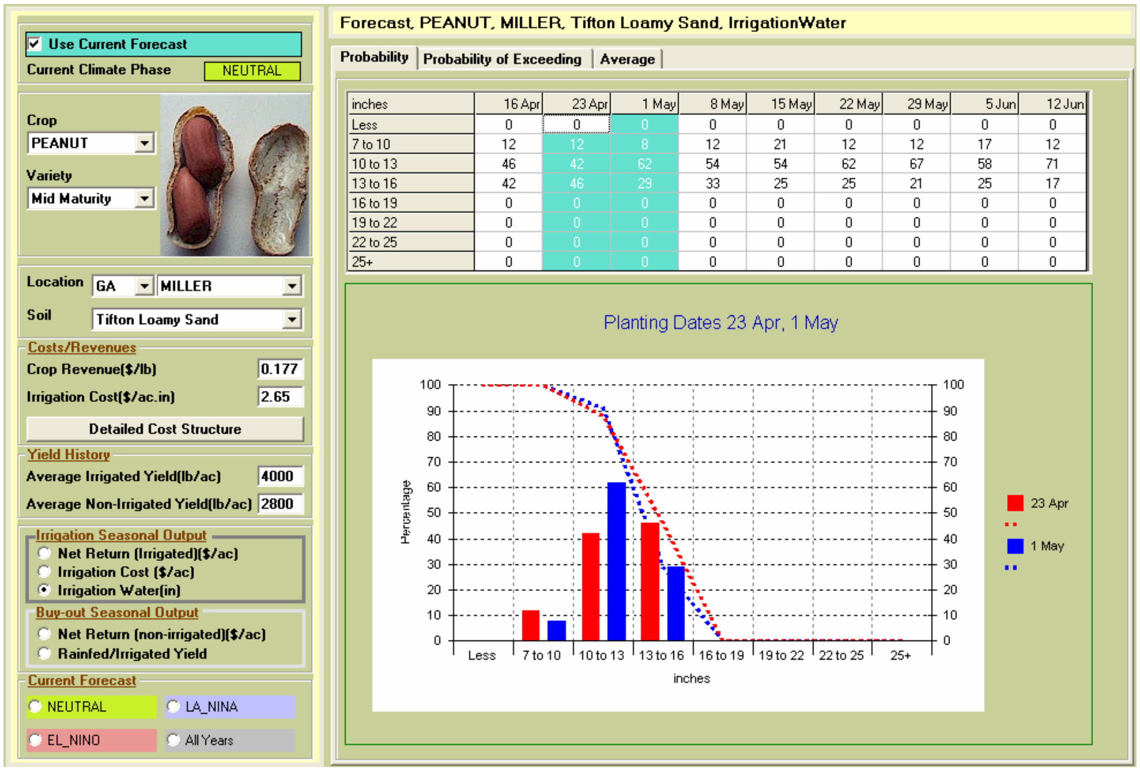


Figure 4. Probability table and histogram of total irrigation consumption for selected planting dates during Neutral years.

Case Study

A comparison of rainfed and irrigated peanut production for Miller County in Georgia is presented to showcase the features of the system and to examine the effect of irrigation, planting dates, and climate on the level of profitability on peanut production. Miller County was chosen because it had the largest area devoted to irrigated peanuts based on the 2002 census of agriculture (NASS, 2004).

The CSM-CROPGRO-Peanut model (Boote et al., 1998; Jones et al., 2003) was used to simulate peanut yield responses to different climate, irrigation, and planting date scenarios. The CSM-CROPGRO-Peanut model, which is part of DSSAT Version 4.0 (Hoogenboom et al., 2004), is a process based model that simulates crop growth and development and the plant and soil water, and nitrogen balances. Long-term historical weather data (1900-2004) were obtained from the National Weather Service (NWS) Cooperative Observer Program (COOP) network and compiled by the Center for Oceanic-Atmospheric Prediction Studies (COAPS), through the SECC. Weather variables include daily maximum and minimum temperatures and precipitation. A solar radiation generator, WGENR, with adjustment factors obtained for the southeastern USA (Garcia y Garcia and Hoogenboom, 2005) was used to generate daily solar radiation data.

Georgia Green peanut cultivar, a medium maturing runner-type peanut variety, was selected as the representative variety for all counties included in the simulation. The soil profile data of three representative soils for each county were obtained from the soil characterization database of the USDA National Resource Conservation Service. Eight planting dates (April 16, 23; May 1,8, 15, 22, 29; June 5 and 12) were considered in the simulation. These represent all possible planting dates at weekly intervals. The typical planting window for peanuts is between mid-April and mid-June. Finally, peanut responses were simulated with and without irrigation and yield and associated variables, including irrigated water requirements and number of irrigation events, were predicted.

In simulating the crop response to irrigation, an irrigation event is triggered when soil moisture at the top 20 inches of the soil profile reaches 60% of the available soil moisture. The soil profile is automatically refilled with water until soil moisture reaches field capacity. Peanut yield was simulated for several counties in Alabama, Florida, and Georgia (Table

1). In addition to peanut yield, the number of irrigation events and total irrigation applied were extracted from the model output files and imported into the PIDSS database.

Table 2 was generated by selecting a particular net return category and the corresponding probabilities under different climate phases. For this particular example, the net return was calculated based on the yield response of peanut grown in Tifton loamy sand. Since three representative soil types in each county were used in the simulation, differences in responses of peanuts grown in each of the soil types are to be expected hence, net returns will be different as well. Under irrigated conditions, the likelihood of obtaining higher net return increased when the planting date was delayed for El Niño years. However, the probability decreased when peanuts were planted after May 29. During La Niña years, growers have a greater chance of achieving net returns of $200-400/acre if peanuts are planted in mid- to late-April. In Neutral years, the calculated probabilities of net return appear to be fairly even across different planting dates. These observations also magnify the importance of proper planting date. While proper planting date is only one phase of peanut production management, it is important to note the impact of this decision on the profitability of irrigated peanuts. The information provided by the system will allow growers to examine all possible planting dates at weekly intervals between mid-April to mid-June, and weigh the risks and benefits of selecting a particular planting date for irrigated peanuts. For growers with large irrigated systems, planting peanuts using a staggered schedule may be a feasible solution to allow him or her to spread the risk.

Table 1. Counties in Alabama, Florida and Georgia that were included in the climate-based cost analysis for peanut production.

Alabama		Florida		Georgia	
Autauga	Dallas	Calhoun	Levi	Baker	Lee
Baldwin	Escambia	Escambia	Marion	Burke	Miller
Barbour	Hale	Gadsden	Okaloosa	Calhoun	Mitchell
Bullock	Henry	Gilchrist	Santa Rosa	Coffee	Seminole
Butler	Houston	Holmes	Walton	Colquitt	Sumter
Clarke	Mobile	Jackson	Washington	Decatur	Tattnall
Coffee	Monroe			Dooly	Terrell
Conecuh	Montgomery			Early	Tift
Covington	Pike			Irwin	Worth
Crenshaw	Russell				
Dale	Washington				
Total = 22		Total = 12		Total = 18	

Table 2. Probabilties (%) of achieving net returns of $200-400 per acre for irrigated peanuts in Miller County, Georgia. Irrigation cost is set at $2.65 per acre-inch

Planting date	Neutral	El Niño	La Niña
Apr 16	33	8	58
Apr 23	38	8	50
May 1	38	8	50
May 8	38	17	33
May 15	25	25	33
May 22	38	25	25
May 29	38	42	42
June 5	29	42	33
June 12	25	25	42

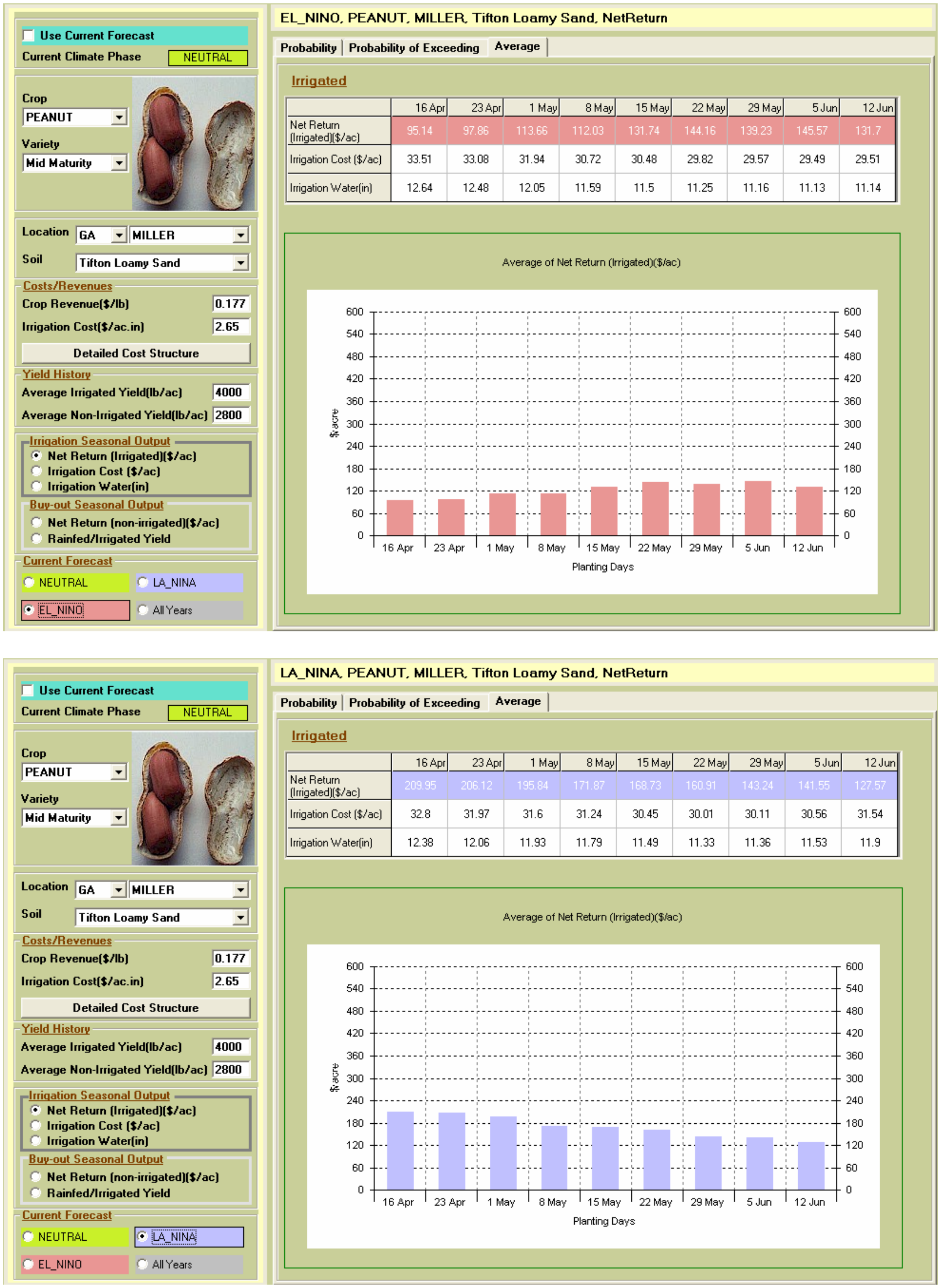
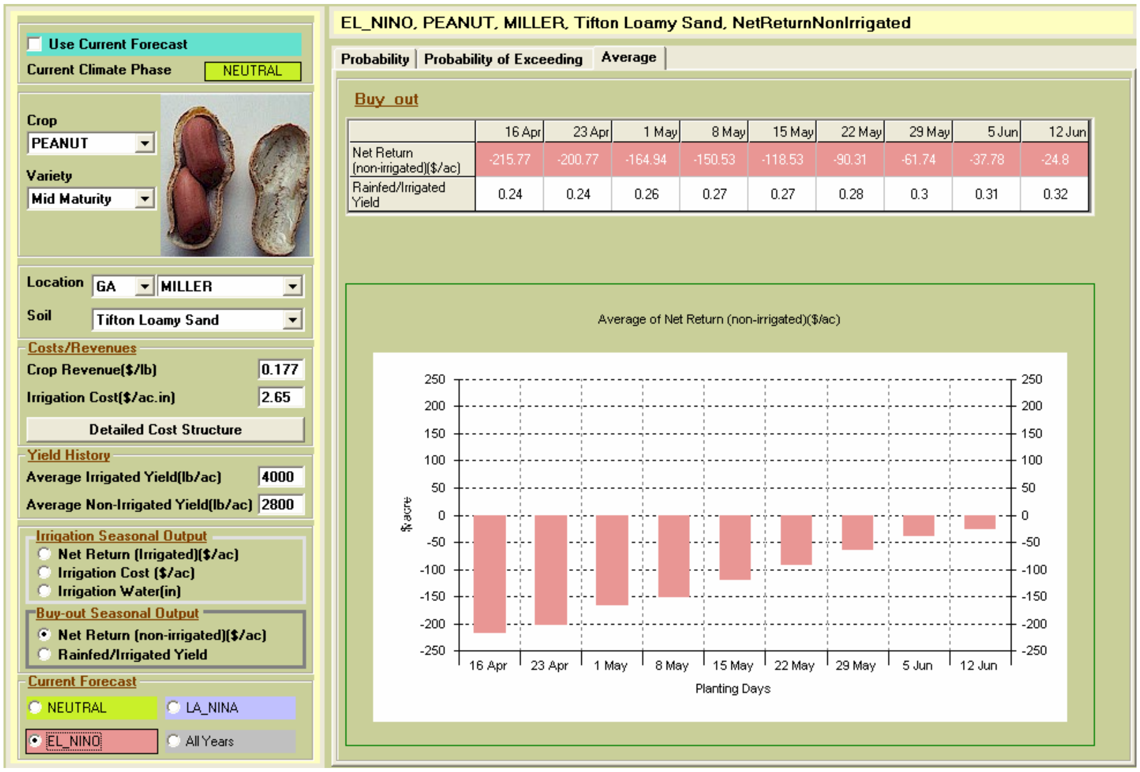


Figure 5. Average net return of irrigated peanuts for different planting dates under El Niño (top) and La Niña (bottom).



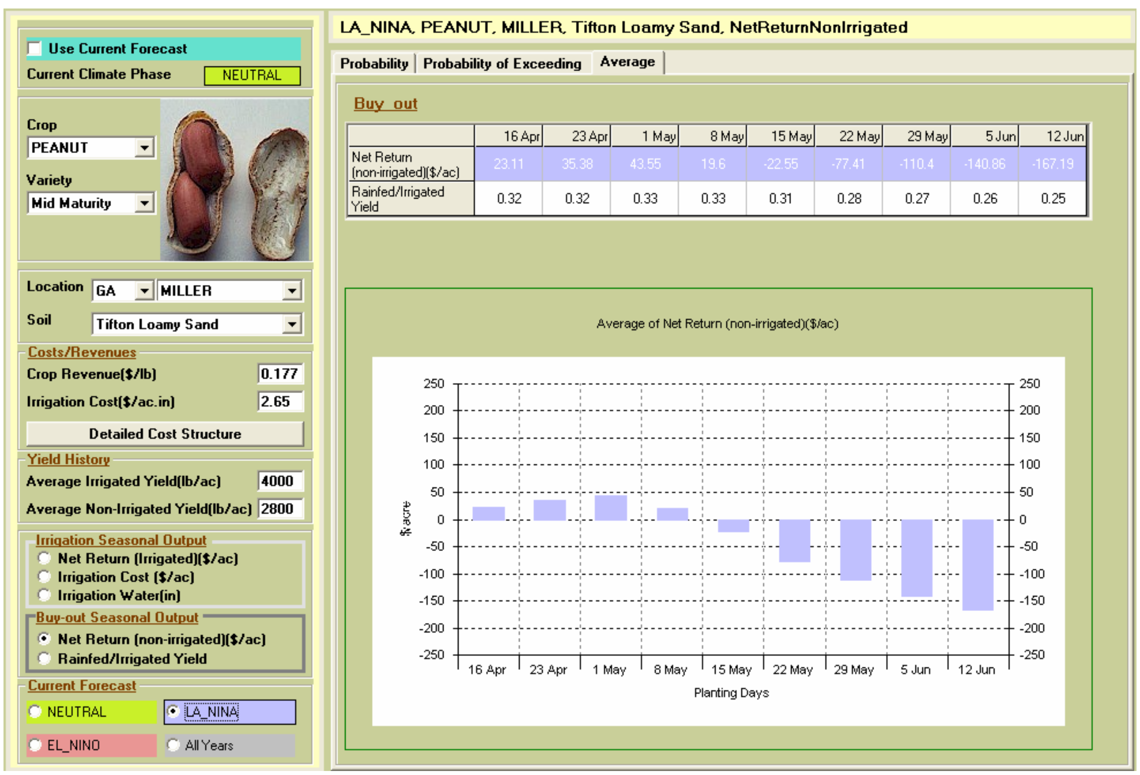


Figure 6. Average net return of non-irrigated peanuts for different planting dates under El Niño (top) and La Niña (bottom).

Under El Niño, average net returns increased from $95.14 per acre for an April 16 planting date to $145.57 per acre for peanuts planted on June 5 (Fig. 5). In La Niña, the net returns ranged from $127.57 to $209.95 per acre for irrigated peanuts, and followed a decreasing trend as planting date was delayed. The trends observed for this case study may not be the same for all soils and counties included in the PIDSS database. Nonetheless, average net returns are expected to be positive under irrigated conditions.

This decision support system also allows the user to examine the economic impact under rainfed conditions. For example, dryland peanut production in Miller County, Georgia is profitable in La Niña years if peanuts are planted between April 16 and May 8 (Fig. 6). Delayed planting will result in significant economic losses ranging from $22.55 per acre to $167.19 per acre for peanuts planted on May 15 and June 12, respectively. Under El Niño, non-irrigated peanut is not a profitable endeavor for most planting dates because of low yields. Regardless of planting date and ENSO phase, average net returns of non-irrigated peanuts are considerably lower compared to irrigated peanuts.

Summary

The peanut irrigation decision support system was developed to assist growers and to provide information on the levels of profitability of planting peanuts with and without irrigation. The CSM-CROPGRO-Peanut model was used to simulate peanut yields under irrigated and non-irrigated conditions from 1900-2004 for several counties in Alabama, Florida and Georgia. Results of the crop model simulations were imported into the PIDSS database. The decision support system provides the probabilities of achieving net returns for different planting dates and soil types for main peanut-producing counties in the southeastern US under different climate scenarios. The tool also provides probability distributions of the seasonal cost to irrigate peanuts and the amount of water that would be required.

A case study and an example analysis was conducted for irrigated and rainfed peanuts for Miller County, Georgia. Under irrigated conditions, average net returns increased when peanuts were planted between April 16 and June 5 in El Niño years. In La Niña years, the net returns followed a decreasing trend as planting date was delayed. Non-irrigated peanut was found not to be profitable in El Niño years for most planting dates because of low yields. In La Niña years, dryland peanut production was only profitable when peanuts were planted between April 16 and May 8.

The prototype will be demonstrated to groups of stakeholders consisting mainly of county extension agents and growers. After additional testing and evaluation, the prototype irrigation decision aid will be deployed as a web-based tool on the AgClimate web site (www.AgClimate.org). In addition, the program will serve as a platform for other row crops (e.g. cotton, corn, soybean) that will be included in the irrigation return analysis tool in the near future.

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