THE COTTON WIZARD: A QUANTITATIVE DECISION TOOL FOR COTTON VARIETY SELECTION

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Abstract

The Cotton Wizard is a computer implementation of a cotton variety selection model intended to assist decision makers in variety selection. The program uses objective data generated by agricultural experiment stations across the U.S. Cotton Belt, or from other sources provided by the program user. The decision criteria for variety selection is based on expected economic return (mean net revenue) of a variety and the variability of returns (coefficient of variation). Total revenue is calculated from lint prices and seed prices, and lint and seed yields. Lint and seed prices are determined by their respective quality characteristics. Adjustments are made for costs which may differ among varieties, such as planting seed cost, and harvest and ginning costs. Users are provided with information on varieties—such as mean net revenue (total revenue - costs), variability in net revenue, and agronomic characteristics—to aid in the decision process. The program is distributed as a Microsoft Windows compatible product.

Introduction

Variety selection is a significant determinant of the profitability of a farm, and is one of the fundamental decision-making processes faced by producers and farm managers. When selecting a cotton variety, the decision maker must determine the most profitable variety for a given set of environmental conditions (e.g., weather, soil structure and composition, pest, weed, and disease occurrence, etc.). Selection of cotton (*Gossypum hirsutum*, L) varieties is made somewhat more difficult than is the case for other crops because of the characteristics of the cotton plant, particularly that two products, lint and seed, are produced, and that each product is priced according to a number of quality attributes (fiber strength, length, micronaire, color grade, etc., for lint; oil %, ammonia %, etc., for seed). Thus, in selecting cotton varieties, decision makers must consider the expected performance of varieties (i.e., expected lint and seed yields) for the set of environmental conditions predominant at their particular location, and also the expected quality attributes of lint and seed for each variety that affect their respective prices.

The analysis of data and information for variety selection is done in different manners. One approach consists of selecting varieties from a catalog (Metzer and Supack, 1993; Townsend et al., 1994). This approach provides the decision maker with varietal performance and agronomic characteristics of each variety; however, data analysis from catalogs can be a cumbersome process given that a large number of performance and agronomic traits are usually included. Thus, there is the possibility that a catalog search yields poor results. Another approach to analyzing data for variety selection was provided by Segarra and Gannaway (1994) who used stochastic dominance with respect to a function to rank cotton varieties and select the most profitable ones. The variables used in this selection procedure include mean profit derived from lint (as a function of its yield and quality attributes) and variability. Another approach to variety selection was proposed by Gellner (1989) who used past yield data (3-year averages selected from a 16-year period) to predict superior yielding spring wheat and oat cultivars. His selection criteria was based solely on mean yields and did not include variability. The results obtained by Gellner demonstrate that the best predictions are made when using the last three years of data. Kang (1993) proposed that the selection of varieties should be done using both mean yields and variability even when short-term data are employed. Kang found that variety selection based on these parameters has positive economic effects for producers over time. Entities such as CIMMYT (Centro Internacional de Mejoramiento de Maiz y Trigo) include mean yields and variability in the selection of new cultivars. The variety selection program developed at CIMMYT is noteworthy in that the selected cultivars must have the highest yields and the lowest variability across environments (Austin and Arnold, 1989). The approaches previously described use objective data generated from experimental trials. Other approaches use data generated by decision makers' perceptions about yields and quality (i.e., subjective data). Wiley (1994) developed a method to assess economic performance of cotton genotypes using subjective yield and lint quality data.

Variety selection for most crops is based on mean return and/or variability of a single output. By comparison, cotton is a crop that produces two outputs, lint and seed. Most research, breeding programs, and economic analysis in cotton are concerned with lint (including its qualitative and quantitative aspects) because it accounts for about 87% of the crop's revenue (Kinard, 1993). Research involved with cottonseed is mainly concerned with its characteristics as planting seed, and not as an output of cotton production. Notwithstanding the fact that cottonseed accounts for only 13% of the crop's total revenue, it is important to include the seed component in the crop's total revenue, and thus in decisions concerning variety selection.

An important aspect of variety selection is the integration of selection procedures into a computer application to allow fast and efficient analysis of large quantities of data by a wide range of individuals. During recent years microcomputer use in agriculture has become popular among producers, consultants, and technicians (Putler and Zilberman, 1988). This trend was accompanied by

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development of software aimed at assisting managers in various situations. Computer applications range from crop growth models to models that simulate the dynamics of specific pests and diseases (Porter, 1995). Within this range of applications, some of these models assist producers in selecting varieties, but few of them include cotton as part of their crop list. A review of microcomputer applications used in variety selection is provided by Lauer (1995).

There are two specific computer applications for selecting cotton varieties, the Texas Cotton Variety Selection Model—TECOVA (Wiley, 1994) and GINNet (Chewing, Zeplin, and Vodicka, 1995). TECOVA measures varietal performance based on two measures, mean revenue and variability, which are estimated using subjective probability distributions of lint yield and quality characteristics. GINNet measures varietal performance using objective probability distributions generated from individual producer data. Although it can be used for variety selection, the main objective of GINNet is to assist ginners and producers to "improve cotton profits through rigorous analysis of USDA HVI data." Both models are focused on the impact of lint yield and quality on total revenue, and ignore the seed component as part of a producer's income.

Specific Problem and Objectives

Selecting a cotton variety to plant is a difficult decision faced by cotton producers every year. To select an appropriate variety, a large amount of information must be analyzed to determine comparable estimates of economic and agronomic performance for each variety under consideration. Such diverse factors as lint quantity and quality, seed yield, seed quality, gin turnout, expected revenue and variability of revenue (risk) need full consideration before an informed decision can be made. However, the amount of data that must be considered in such an analysis often precludes decision makers from considering all necessary information. As such, an objective and efficient method of analyzing cotton data is needed.

An objective method of comparing cotton varieties is available through the use of a quantitative (mathematical) decision model. However, considering the large amount of data that is necessary for proper comparison of cotton varieties, a quantitative model, although providing objectivity, does not solve the logistic problem inherent in mathematical analysis of large amounts of data involving complex relationships. As such, a cotton variety selection model developed by Olaciregui (1996) has been implemented as a computer program called the "Cotton Wizard." The program automates the implementation of the decision model, thus solving both the logistic and objectivity problems. A description of the Cotton Wizard program is provided in this paper.

Program Description

The Cotton Wizard program is designed to assist decision makers in the selection of cotton varieties. The main features of the program are:

- Use of cotton performance data generated by agricultural experiment stations;
- Inclusion of the seed component (as well as the lint component) as part of a cotton crop's total revenue;
- Use of mean return and variability simultaneously in variety selection.

The decision rule for variety selection combines expected economic return (mean net revenue) of a variety and the variability of returns (coefficient of variation), and the decision maker's risk aversion level. Other economic and agronomic information on lint and seed components can be used as extra decision criteria for variety selection. Varietal performance is calculated using the National Cotton Variety Test dataset (USDA, ARS). These data are a compilation of cotton performance test data from agricultural experiment stations across the U.S. Cotton Belt.

The Cotton Wizard is a user-friendly computer application that works in the Microsoft Windows environment. The program automates the previously time-consuming task of searching through and analyzing large amounts of agronomic and economic data on cotton varieties. The program is easy to use and has flexibility with respect to the information that can be obtained. Data sources are also flexible, i.e., users can use their own data as long as certain guidelines on data format are followed. The program is interactive, requiring user input to obtain results. Users with some knowledge of statistics will understand the results provided by the program more easily than users without statistical experience.

Overview

The Cotton Wizard computer program is based on the cotton variety selection model developed by Olaciregui (1996). This model uses two measures to assess the economic performance of cotton varieties--mean net revenue (MNR) and coefficient of variation (CV). The components of net revenue (used in calculating MNR and CV) include lint and seed yield and their respective prices adjusted for quality characteristics, and specified costs (i.e., costs that vary among varieties and are therefore important in varietial comparisons):

$$NR = (PL*LY + PS*SY) - TC$$

where:
NR = net revenue;
PL = lint price;
LY = lint yield;
PS = seed price;
SY = seed yield;

TC = total of specified costs.

Figure 1 provides an overview of the cotton variety selection model. The variety selection process can be divided into three steps. The first step is the calculation of net revenue from total revenue and specified costs for each variety being considered. Total revenue is determined from the yields of lint and seed produced by a variety and the prices of lint and seed. Lint and seed prices are determined by their respective quality characteristics. Specified costs are subtracted from total revenue to determine net revenue for a variety. Specified costs should include costs that differ across varieties (i.e., planting seed cost, and harvest and ginning costs). Other costs can also be included at the discretion of the decision maker.

The second step in the variety selection process involves calculation of economic performance measures of a cotton variety. Two economic performance measures--MNR and CV--are calculated from the net revenues over a given number of years. MNR is calculated by taking the mean of a variety's yearly net revenues over a specified period. MNR provides a measure of future expected net revenue for the variety. CV is calculated by dividing the standard deviation (SD) of net revenue by MNR for the period under consideration (i.e., CV=SD/MNR). CV provides a measure of the risk associated with planting a particular variety. These economic performance measures are based on past performance of a variety, however, in variety selection they provide an indication of how a variety might potentially perform in the future (i.e., the future expected economic performance).

The third step in variety selection involves the selection of a cotton variety to plant. Variety selection is made by considering MNR, CV, and the decision maker's risk aversion level. The risk aversion level quantifies the decision maker's willingness to take on extra risk (higher CV) in exchange for higher potential return (higher MNR). For a given set of varieties under consideration, different decision makers with different risk aversion levels may select different varieties. For example, a decision maker exhibiting low risk aversion will select varieties with high MNR, giving little consideration to CV. By comparison, a decision maker with high risk aversion will select varieties with low CV's, giving somewhat less weight to the MNR of varieties than would the former decision maker. In short, a decision maker should select varieties that are consistent with his feelings toward risk and return. A more detailed explanation of the selection process using MNR and CV is provided below.

Specific Features

Specific features of the Cotton Wizard computer program are addressed below.

Data--The dataset provided with the Cotton Wizard program was obtained from the National Cotton Variety Testing Program (USDA, ARS). The dataset currently contains 16 years of lint, seed, and yield information for the period 1980-1995. The dataset contains information on all major varieties grown in performance trials conducted across the U.S. Cotton Belt during the period. The data were initially provided by the various state agricultural experiment stations in each area of the Cotton Belt (over 50 locations). It should be noted that users can use their own dataset if the one provided does not adequately meet their needs.

Seed Component--Most agronomic and economic research on cotton is concerned with cotton lint because lint accounts for a major portion of cotton revenue. By contrast, research on cottonseed is mainly concerned with its use as an input to cotton production (as planting seed) rather than its value as an output. Recently, however, renewed interest in seed quality issues has developed, providing an outlet for the Cotton Wizard's ability to analyze seed quality (and quantity) across varieties.

Using MNR and CV in Variety Selection--MNR and CV are based on past performance of a variety, however, in variety selection these measures provide an indication of how a variety might potentially perform in the next year (i.e., the expected future economic performance). MNR provides a measure of next year's expected return of a variety, while CV provides a measure of the variability in the return from year to year. In variety selection, the decision maker should consider simultaneously MNR and CV.

Mean Net Revenue (MNR) is an average of the yearly past total revenues of a variety for a given time period minus the average of the user specified costs over the same period. As such, the interpretation of MNR takes on different meanings, depending on the types of "other costs" supplied by the user. If only costs that differ across varieties are supplied, MNR is useful only for comparing varieties, not for predicting profits. When all costs are included, net revenue represents the expected accounting profit; or if only variable costs are included, net revenue represents a contribution margin (i.e., return to fixed assets).

Coefficient of variation (CV) is the average yearly variation in net revenue (standard deviation) per dollar of expected return (i.e., standard deviation divided by MNR). CV provides a measure of risk (or uncertainty in return). If CV for a variety is high, one can expect the yearly variation in net revenue for the variety to be high. As such, planting a variety with a high CV involves more risk than planting a variety with a low CV because returns can be substantially below (or above) the expected (historical average) MNR.

When deciding which variety to plant, the user should consider both MNR and CV of a variety and the amount of risk he is willing to assume for a given level of potential return. The choice depends on the individual user's

willingness to take on extra risk (higher CV) in exchange for higher potential return (high MNR). For example, consider the following hypothetical situations: variety B has MNR=$450 (per year) and CV=.18; data for variety A is shown below. The process of choosing a variety (for three situations) is explained in the right-hand column.

Situation	MNR(A)	CV(A)	Choice
Situation 1	$500	0.15	The obvious choice is variety A because it has a higher expected return (high MNR), and lower risk (low CV).
Situation 2	$425	0.12	The choice depends on the user's preferences. Variety A has a lower expected return (low MNR), but there is less risk associated with planting it (low CV).
Situation 3	$600	0.25	As in Situation 2, the choice depends on the user's preferences. Variety A has a substantially higher expected return (high MNR), but also has greater risk associated with that return (high CV).

In variety selection, the choice depends on each individual decision maker's risk aversion level. With the performance measures (MNR and CV) provided by the Cotton Wizard program, it is possible for a decision maker to determine which cotton variety/varieties are appropriate for his situation.

Program Operation

Users of the Cotton Wizard computer program are provided with an intuitive interface for program operation. The interface consists of five screens:

1. **Initial Settings**—The user chooses a location, years for analysis, components for analysis (users can choose one, or more, of lint yield, lint quality, seed yield, and seed quality) and the varieties to be included in the analysis.

2. **Constraints**—The user enters searching constraints to limit the upper and lower values (as appropriate) for the following characteristics; lint yield, fiber strength, micronaire, fiber length, Rd (reflectance) value, H+b (yellowness) value, seed yield, oil percent, and ammonia percent. The user can enter constraints for all, some, or none of the above characteristics.

3. **Prices and Costs**—The user enters base prices for lint and seed and the following costs: harvest and ginning, planting seed, other. Also, the user chooses whether to determine premiums/discounts using the CCC Loan Schedule or the hedonic pricing model (available for Texas-Oklahoma only). The hedonic model develops premiums/discounts based on statistical analysis of market prices received for individual cotton lots and the quality characteristics of each lot (Brown, et al., 1995).
4. **Results**—This screen displays a results table which can be copied into other programs or printed on a printer. On this screen, the user chooses which characteristics to graph (any of the characteristics listed in the results table can be graphed). An example results screen (Figure 2) and an example results table (Table 1) are provided.

5. **Graphs**—This screen displays high quality 2-D and 3-D color graphs of the information selected for graphing on screen 4. Graphs can be printed, copied into other programs, or saved for later use. An example graphics screen is provided (Figure 3).

Program Objectives

An important objective in creating the Cotton Wizard program was to provide a decision tool for cotton variety selection that would solve the logistics problem of analysis of large amounts of data. Additional objectives were to make the program user friendly and as flexible as possible so a wide range of users could be successfully serviced by the program. The Microsoft Windows environment was found to be appropriate for meeting both objectives due to its ease of use, portability of user knowledge from one program to another, and its enhanced flexibility.

To meet the objective of user friendliness, a highly graphical and intuitive interface for program operation was created (as described above). Users are asked for all necessary information, and need only learn and remember basic skills to effectively operate the program. Further, the program output was designed for ease of interpretation and manipulation by the user. The results table can be printed, if desired. A searchable help file is included with the program to provide quick reference to the user.

To meet the objective of flexibility, several features were designed into the program. These include: (a) the option to use a dataset other than the National Cctton Variety Test dataset provided; (b) the option to include in the analysis whatever costs are deemed necessary by the user; (c) the option to choose information to graph and to allow adjustment of the graph; and (d) the option to choose lint pricing methods, either CCC Loan Schedule or hedonic price model (at present, this choice is only available in Texas). In addition, the program allows the option to choose the components (lint and seed yields and qualities) to use in the analysis. This allows the user the flexibility to compare varieties using only the lint component (ignoring the seed component). It is important to point out that the program is data driven, and the option for using user-supplied datasets affords a great deal of flexibility.

Specifications and Availability

The minimum system requirements to run the Cotton Wizard program are:

- IBM or 100% compatible computer with an 80386 or greater processor
- MS-Windows 3.1, 3.11, or Windows 95
- 4 MB RAM (8 MB recommended)
- 12 MB free hard drive space
- Color monitor (SVGA recommended)
- Mouse or other pointing device

The Cotton Wizard program was written in Visual Basic 4.0. It makes use of many Windows features, including dynamic data exchange (DDE), event driven programming, and efficient system control of graphics, printing, and disk access. Datasets are in Microsoft Access format, and the provided database uses extensive SQL programming to provide efficient calculations and data access. Users need not own Microsoft Access to use the Cotton Wizard, however, users desiring to use their own datasets will need Access to convert their datasets into an appropriate format. For more information on user supplied datasets, see User's Manual for the Cotton Wizard.

Documentation of the Cotton Wizard program is provided in the User's Manual (Lopez, et al., 1996). The documentation includes details on how to use the program and the options available in the program. A complete explanation is provided of the calculations (including equations) made by the program. The User's Manual is distributed with the program.

The Cotton Wizard program is available from the Department of Agricultural and Applied Economics, Texas Tech University (MS 2132, Lubbock, TX 79409). The program can be downloaded from the Internet without written documentation at: http://www.ttu.edu/~agecon/cottonwiz.zip. Updated datasets will be available approximately every year as new National Cotton Variety Test data are published.

Discussion

The cotton variety selection model described herein provides a means for comparing the economic and agronomic performance of cotton varieties. Economic performance is based on mean net revenue (a measure of expected future return) and coefficient of variation (a measure of expected future variability (risk) of return). The use of MNR and CV is supported by both agronomic and financial/economic research. It is important to note that the performance measures provided (e.g., MNR and CV) are intended only for use in comparison of varieties. As such, the user is cautioned that the results may not provide an accurate estimate of the future performance of a variety in a particular farming situation. However, users can be assured that every effort has been made to provide accurate comparisons of varietal performance.

The computer implementation of the cotton variety selection model—as the Cotton Wizard—affords the user an efficient means for comparison of cotton varieties. Using the program, users can simultaneously consider complex agronomic and economic characteristics of many varieties, allowing informed decisions that would otherwise be difficult or even logistically impossible. In short, the Cotton Wizard program reduces the cost of the decision making process by allowing quick and efficient manipulation of large volumes of data, and by providing automated analysis of such.

Although the Cotton Wizard program is mainly designed for variety selection, there are alternative uses. It can be used for data display and analysis (tables and graphs) to facilitate the interpretation of available information. This use is relevant to local agricultural experiment stations and the National Cotton Variety Testing Program which publish large amounts of variety performance data. Agronomists and technicians in agricultural experiment stations can use the program (with user-supplied datasets) for comparison of different seed treatments, fertilizer levels, irrigation systems and schedules, and other managerial practices. The program can be used by agricultural economists in economic analysis of cotton production, including the seed component which has largely been ignored in previous research. In determining what cotton producers receive for cottonseed, oftentimes, seed production (yield) and seed quality are not included in the valuation process. The Cotton Wizard program can be used to determine the impact of ignoring seed quantity and quality on producer net revenue and variety selection.

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Table 1. Results for Lubbock irrigated, 1990-93.

Econ. & Agro. Information Information	Paymaster HS26	Acala 1517-88
Lint Revenue (LR)($/ac)	610.89	494.09
Seed Revenue (SR)($/ac)	75.78	60.67
Total Revenue (TR)($/ac)	686.67	554.76
Specified Costs ($/ac)	129.54	118.07
Net Revenue (NR)($/ac)	557.13	436.69
Std. Dev. Of NR ($/ac)	207.65	228.8
Coef. Of Var. of NR	0.3	0.41
Correlation of LR and SR	1	0.98
LR as % of TR	89.00	89.10
SR as % of TR	11.00	10.90
Lint P/D($/lb)	0.0094	0.0158
Seed Grade	101.9	101.14
Lint Yield (lb/acre)	860.32	689.05
Fiber Strength (gr/tex)	28.33	30.6
Micronaire	4.49	3.73
Fiber Length (32s)	34	36.5
Rd (Reflectance) (%)	80.72	80.93
Hunters +b (Yellowness)	8.43	8.55
Color Grade	21	21
Leaf Grade	4	4
Leaf Type	N/A	N/A
Seed Yield (lb/acre)	1489.29	1189.95
Oil % (Wet Basis)	18.42	18.01
Ammonia % (Wet Basis)	3.87	4.02

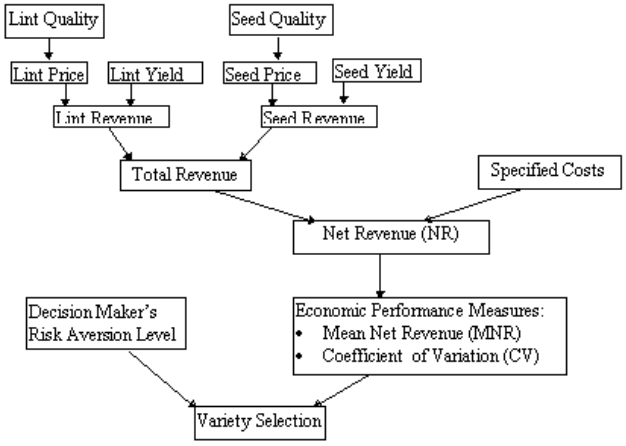

Figure 1. Diagram of the cotton variety selection model.

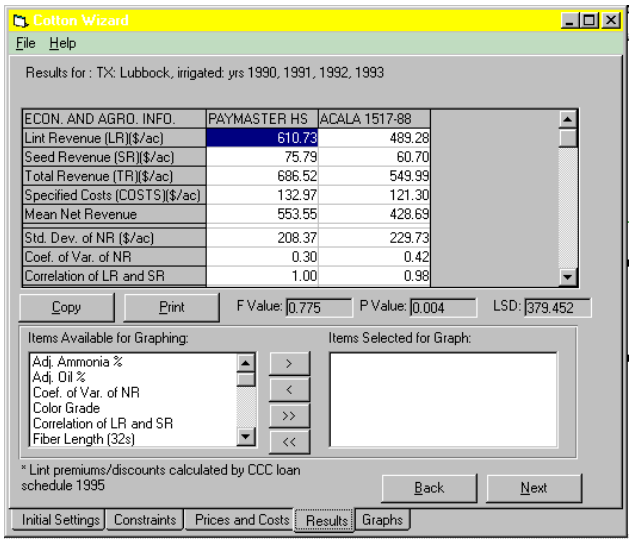

Figure 2. Screen 4, results.

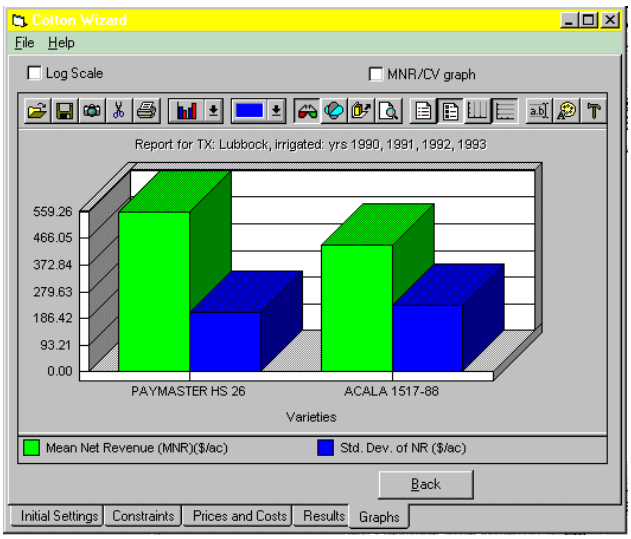

Figure 3. Screen 5, graphs.