ARE CURRENT CROP AND REVENUE INSURANCE PRODUCTS MEETING THE NEEDS OF TEXAS COTTON PRODUCERS

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Abstract

An empirical procedure was developed to analyze the cost effectiveness of alternative crop insurance products in terms of increasing producer net returns and minimizing variation in net returns. Results indicate that CAT was the overwhelmingly preferred MPCI option for all scenarios. The ranking of the other MPCI options was consistently 50/100, 60/100, and 75/100 in all scenarios. The CRC options, with the exception of one scenario, ranked 50, 60, and 75 percent, respectively.

Cotton production contributed an average of $5.27 billion per year to the United States economy from 1988 through 1994 (National Agricultural Statistics Service [NASS], 1999). More than 14.5 million acres of cotton were planted in the U.S. in 1999, with more than 13 million acres harvested and about 16 million bales of cotton produced. Texas accounted for about 42 percent of planted acres, about 39 percent of harvested acres, and over 31 percent of total cotton production in 1999 (Texas Agricultural Statistics Service [TASS], 2000). Cotton production, like any other agricultural enterprise, is inherently risky. Cotton producers are subject to unpredictable, random shocks, such as adverse weather, pest infestations, and other natural disasters, such as drought and flooding. Supply uncertainties, coupled with inelastic demand for many agricultural products, lead to price movements that are generally more volatile for farm products than those commonly experienced in other sectors of the economy (Goodwin and Smith, 1995).

In the past, producers have relied on the federal government for protection from price and yield variability. This protection came in the form of a federal crop insurance program, ad hoc disaster payments, and deficiency payments. Deficiency payments were made when the price level of the commodity fell below the target price set by the federal government. The target price acted as a floor price, guaranteeing a level of returns per unit of a commodity. However, significant changes have occurred in U.S. farm policies. The most recent of which are embedded in the Federal Agricultural Improvement and Reform (FAIR) Act of 1996. The elimination of deficiency payment provisions by the 1996 FAIR Act has affected expected returns and the income variability faced by producers (Skees et al., 1998). The lack of deficiency payments to compensate for commodity price variability, coupled with the flexibility of producers to switch crops from year to year, have increased revenue risks for producers. Although the federal government has attempted to reduce its role in providing price and income support, there has been an increasing emphasis on crop and revenue insurance (Skees et al., 1998). Pressure to reform crop insurance products has resulted because of low participation, poor actuarial performance, and the existence of ad hoc disaster payments (Skees et al., 1998). These issues were addressed by the Crop Insurance Reform Act of 1994, which prohibits ad hoc crop disaster programs, unless the funds are appropriated from other agricultural programs. The 1994 act also directed the Federal Crop Insurance Corporation (FCIC) to develop a pilot crop insurance program to provide farmers with coverage against reduced income as a result of reduced yields and/or prices (Miller et al., 2000). Although the movement of agricultural policy in the United States toward less government involvement has left producers exposed to higher levels of production and marketing risk, there are many risk management practices that are available to producers to help substitute for government programs. Some of these practices are forward contracting, hedging with futures and options, and crop insurance. The general objective of this study was to develop and illustrate the application of an empirical procedure to evaluate the cost effectiveness of various crop and revenue insurance products as risk management tools for Texas cotton producers.

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Methods and Procedures

Precise estimates of yield and price distributions are needed to evaluate the cost effectiveness of crop and revenue insurance products and their impacts on a farmer's net worth. Pooled yield data was used to estimate irrigated and dryland yield distributions at the farm level in three West Texas regions (the Southern High Plains, the Northern High Plains, and the Northern Low Plains) covering thirteen counties. Farm level producer yield data were collected from the Texas Agricultural Extension Service (Fincham, 1999) and included five to ten years of producers' yield history. The data consisted of the number of acres planted, the actual realized yield in pounds per planted acre, the location of the farm, and the farming practice (i.e., irrigated or non-irrigated).

The limited number of years of farm level data available was not sufficient to precisely quantify the trend and other critical features of the yield distributions. Therefore, aggregate time series yield data (TASS, 1970-98) were used to assist in the estimation of the yield distributions and their changes through time. Price data were collected from the National Agricultural Statistics Service (NASS). The state-level data consisted of annual price data from 1934 to 1998, and were used to estimate the price distribution faced by Texas cotton producers. A multivariate parametric model, developed by Ramirez (1997) and expanded by Ramirez et al. (1999), was used to estimate the yield and price distributions. This approach estimates a multivariate, nonnormal distribution that can accurately and separately account for skewness, kurtosis, heteroscedasticity, and the correlation among the random variables of interest, irrigated and dryland cotton yields and prices, in this case.

Once the parameters for the price and joint bivariate yield distributions were estimated, they were used to simulate 15,000 draws from each of these estimated distributions. This simulation technique, developed by Ramirez (1997), incorporates, when appropriate, the factors affecting the mean of the yield and price distributions through time and space, as well as heteroscedasticity, autocorrelation, right or left skewness, kurtosis, and the correlation between dryland and irrigated cotton yields. The simulated yield and price series were used to develop an empirical procedure to analyze the cost effectiveness of alternative crop insurance products in terms of increasing producer net returns and minimizing the variation in net returns. To compare different crop and revenue insurance products, net returns per planted acre were estimated over a planning horizon. Total revenue distributions were first calculated by multiplying the simulated yields by the simulated prices:

(1) $TR = SY.*SP$

where TR represents an n×T matrix containing n=15,000 total revenues per planted acre from T time periods (T is the total number of years included in the planning horizon), SY is an n×T matrix of simulated yields containing n random draws from the estimated yield distribution for each of the T time periods under analysis, and SP is an n×T matrix of simulated prices containing n random draws from the estimated price distribution for each of the T time periods in the evaluation. Net revenues were then calculated by subtracting production costs from and adding cottonseed revenues to the total revenues:

(2) $NR = TR - PC + SR$

where NR is an n×T matrix containing n net revenues per planted acre from T time periods, PC is an n×T matrix containing the production cost per planted acre (that was held constant through time and across simulated yields) less insurance and returns to management, and SR is an n×T matrix containing the seed revenues per planted acre associated with the n simulated yields for the T time periods in the analysis. Production costs were obtained from the Texas Agricultural Extension Service's (TAEX) crop budgets for each region (TAEX, 2000). Cottonseed yields for each region was calculated based on the simulated lint yield and assuming the same ratio of seed to lint (in pounds) as the TAEX budgets. Cottonseed revenues were calculated assuming the price for cottonseed to be a three-year average of the price as reported in TAEX budgets.

The final step in estimating net returns was to subtract insurance premiums and add indemnity payments, when applicable:

(3) $NRet = NR - IC + IR$

where NRet is an n×T matrix containing n net returns per planted acre for the T time periods, IC is an n×T matrix containing the cost of insurance premiums for the T time periods, and IR is an n×T matrix containing revenues from insurance indemnity payments paid for the T time periods.

Insurance premiums were calculated using an estimated APH, an estimated base price, and premium rates obtained from USDA's Risk Management Agency (FCIC, 2000). Regional level rates were calculated by averaging the rates for all counties included in each region. Premium rates were held constant across the planning horizon. The estimated APH was calculated as a moving average of the previous five years' yields:

(4) $APH_t = [SY_{(t-5)} + SY_{(t-4)} + SY_{(t-3)} + SY_{(t-2)} + SY_{(t-1)}]/5$

where APH_t is the nx1 vector of APHs for time period t. If t is the first year of the T time periods in the evaluation, yield simulation vectors would be needed for each of the previous five years in order to calculate the APH vector for time t=1. Thus, a total of T+5 nx1 yield vectors had to be simulated.

The base prices were estimated by a distributed lag model, which was corrected for autocorrelation using the first-order autoregressive process, or AR(1). The estimated model was:

(5) $_{Bpt} = 0.1134 + 0.2093*P_{t-1} + 0.2751*P_{t-2} + 0.2449*P_{t-3}$
(0.0628) (0.0960) (0.0921) (0.0955) $R^2 = 0.8799$

where BP_t is the base price in time t, P_{t-1} is the market price observed in time t-1, etc. Base prices were estimated for each of the ten years in the planning horizon (2000 - 2009) and were assumed to be the same for both MPCI and CRC insurance products.

The premium rates are dependent upon the APH and coverage level chosen. Indemnity payments were calculated for each iteration (I = 1,…,n) of each time period (t). If the insurance product was an MPCI product, the indemnity payment was calculated as:

(6) $IR_{it} = [(APH_{it} * CL) - SY_{it}] * BP_t * PE$

where IR_{it} is the ith element of the nx1 IR vector for year t, CL is the percent yield coverage election chosen, and PE is the price election chosen. The indemnity was only calculated when the actual yield fell below the guaranteed yield, or when $SY_{it} < (APH_{it} * CL)$. Otherwise, IR_{it} was set equal to zero. If the insurance product was a CRC product, the indemnity payment was calculated as:

(7) $IR_{it} = \{[APH_{it} * Max(BP_t, SP_{it})] * CL\} - (SY_{it} * SP_{it})$

only if the actual revenue fell below the guaranteed level, or when $(SY_{it} * SP_{it}) < \{[APH_{it} * Max(BP_t, SP_{it})] * CL\}$. Otherwise, IR_{it} was set equal to zero. The simulated net returns under different crop and revenue insurance products were used to analyze the efficacy of the insurance products from the perspective of cotton producers. The statistical measures used to compare insurance products were the mean, standard deviation, and the coefficient of variation of the simulated net returns, the probability of receiving an indemnity payment, the premiums paid and indemnity payments received over a ten-year planning horizon, and the difference between premiums and indemnities. A third-degree stochastic dominance analysis was also used to compare and rank crop insurance products for Texas cotton producers.

Four different MPCI products (CAT, 50/100, 60/100, and 75/100), three different CRC products (50, 60, 75), and the case of no insurance were compared to determine which, if any, of these seven crop insurance alternatives would be beneficial from producers perspective. This study was conducted over three regions: the Southern High Plains, the Northern High Plains, and the Northern Low Plains.

Results

The estimated distributions for dryland cotton yields in the Northern High Plains, Southern High Plains, and the Northern Low Plains were found to be non-normal, kurtotic and right-skewed, while irrigated yields appear to follow a normal distribution. The mean and variance of both the dryland and the irrigated yield distributions have been changing through time, and are affected by factors such as region and acres planted. This information is useful since actuarially fair premiums can only be calculated under a precise knowledge of the crop yield distributions.

The predicted mean for the yield distribution of irrigated cotton in the Northern and Southern High Plains was approximately 588 pounds per planted acre in 1995, while the predicted mean for the Northern Low Plains was about 486 pounds per planted acre. The standard deviations of the 1995 irrigated cotton yield distributions in the Southern High Plains, Northern High Plains, and Northern Low Plains were estimated at about 266, 219, and 172 pounds per planted acre, respectively. The means of the estimated dryland cotton yield distributions in 1995 were: 228 pounds per planted acre for the Northern and Southern High Plains and 279 pounds per planted acre for the Northern Low Plains. The standard deviations were 189 pounds per planted acre for the Northern and Southern High Plains and 159 pounds per planted acre for the Northern Low Plains.

The estimated mean yield trends suggest that dryland cotton yields in the Texas High Plains incrersed moderately from 1960 to about 1988, and then started to decline, reaching their 1960 levels by 1998. However, low dryland cotton yields were recorded for at least three years between 1990 and 1998, due to adverse weather conditions. These poor yields could be responsible for this apparent reversal in the long-term trend. Alternatively, it is possible that the estimated dryland cotton yield distribution may reflect cyclical weather patterns, indicating that dryland cotton yields have remained relatively stable over the past 30 years. The estimated mean yield trends also indicate that irrigated cotton yields have been increasing since the late 1970's. This increase may be due to the adoption of new irrigation technologies, such as LEPA (Low Energy Precision Application).

The mean of the yield distribution for each region was assumed to be the same at the farm and county levels, but different variances were estimated for each level. The standard deviation of the estimated county level irrigated cotton yield distribution for the year 1989 was about 75 pounds per acre less than the standard deviation of the estimated farm level yield distribution for that year. In the case of dryland cotton, the model indicates that from 1960 to 1998, the standard deviation of the farm level yield distribution was about 50 pounds per acre more than the standard deviation of the county level yield distribution. This is because farm and county level dryland yield variability was found to be changing at the same rate through time. These simulated farm and county level dryland and irrigated cotton yield distributions for 1995 are presented in Figures 1-4. It should be noted that yield right skewness is compatible with West Texas farmers' and researchers' intuition. Given normal rainfall conditions of 6-12 inches during the growing season, dryland cotton varieties can produce 100-500 pounds per acre. Under severe drought conditions, which may occur once or twice a decade, many farms achieve very low, or even zero yields. Extremely high yields (500-700 pounds per acre) may occur every 10-15 years as a result of very favorable temperatures and rainfall amounts during the growing season. Therefore, right skewness of the dryland cotton yield distribution is derived from the right skewness of the rainfall distribution. It should also be noted that average dryland county level yields per planted acre are seldom below 75 pounds per planted acre, but farm level yields have a much higher probability of falling between zero and 75 pounds per planted acre.

The estimated price model indicated that cotton prices in Texas have been linearly declining in real terms by about one cent every five years. Cotton prices were also found to be normally distributed, but autocorrelated. Prices were simulated for the years 2000 through 2009 accounting for autocorrelation and using the price distribution the model predicted for each year.

When comparing mean net returns, CAT was the overwhelmingly preferred MPCI option for all scenarios (Tables 1-2). The ranking of the other MPCI options was consistently 50/100, 60/100, and 75/100 in all scenarios. However, if no insurance is considered as an option, it was found to be the second preferred option after CAT for irrigated cotton in the Southern High Plains and the Northern Low Plains. For the Northern High Plains, however, the 50/100 options and 60/100 options were ranked above the no insurance option. In all scenarios, the no insurance option ranked behind CAT and ahead of the 75/100 option. The CRC options always ranked 50, 60, and 75 percent, respectively, but for irrigated cotton, the no insurance option fared better than any of the CRC options, except for the Northern High Plains, where the 50 percent option was preferred to no insurance. In the case of dryland cotton, 50 percent CRC coverage ranked higher than no insurance for both the Southern High Plains and Northern Low Plains. In the Northern High Plains, both 50 and 60 percent CRC coverage levels fared better than the no insurance option. In all scenarios considered, the no insurance option ranked above the 75 percent CRC coverage level.

In all irrigated cotton scenarios, the standard deviation of net returns decreased as the coverage level increased for both the MPCI and the CRC insurance products. All insurance options had lower standard deviations than the no insurance for all dryland cotton scenarios. CAT and 50/100 seemed to reduce the standard deviation of net returns, respectively, but the 60/100 level and, in some cases the 75/100 level, resulted in a higher standard deviation than the CAT and 50/100 levels. This may be due to the fact that the insurance rates for these options (60/100 and 75/100) are overrated for dryland cotton in some regions, resulting in higher premiums and, thus, a greater fluctuation of net returns. All CRC options resulted in lower standard deviations than the no insurance option. However, in two out of three regions, the 60 percent level had the highest standard deviation of all CRC options. This may once again be caused by overrating of this option.

The probability of receiving an indemnity payment in a given year was also calculated for each level of MPCI and CRC. For both dryland and irrigated cotton in all regions, the probability of receiving an indemnity payment for the CAT option was equal to that of the 50/100 level. This is because the MPCI insurance products pay indemnities based on the yield coverage level and both options contain the 50 percent yield protection. As one might expect, the probability of receiving an indemnity payment increased as coverage levels increased for both the MPCI and the CRC insurance options.

Insurance premiums and indemnities were summed across a ten-year horizon to determine if the cost of the premiums was offset by the receipt of indemnity payments. The CAT premium was $0.90 in all regions. For both irrigated and dryland cotton in all regions, the mean sum of insurance premiums and the mean sum of indemnities received increased as coverage levels increased for both the MPCI and the CRC insurance products. CAT was the only insurance option that returned a premium-indemnity surplus for all of the scenarios studied. In all but two scenarios, the 50/100 and 60/100 options also returned a surplus. The 75/100 option returned a premium-indemnity deficit for all scenarios studied. The 50 percent CRC option returned a surplus in four out of the six scenarios, while the 60 percent option returned a surplus in only one scenario. The 75 percent option returned a deficit in all of the scenarios studied. The surplus declined and/or the deficit increased as the coverage level increased in all scenarios for both MPCI and CRC.

The stochastic dominance analysis (Tables 3-4) indicated that the rankings of insurance products are similar to the ones found when comparing crop insurance products in terms of mean net returns. The CAT (50/55) option was the most preferred MPCI option. CAT ranked ahead of all MPCI options, as well as no insurance, in all scenarios studied. This finding was consistent with Skees et al. (1998), who found that CAT increased the ending net worth of a representative farm in the Mississippi Delta. The ranking of the other MPCI options was consistently 50/100, 60/100, and 75/100 in all scenarios. The CRC options were ranked 50 percent, 60 percent, and 75 percent in all scenarios except irrigated cotton in the Northern Low Plains, where the 60 percent option was ranked above the 50 percent option.

Conclusions

The current study compares the efficacy of various crop and revenue insurance products for selected regions in Texas using farm level data. An important aspect of this study is that cotton yield and price distributions were estimated using a procedure that can accurately and separately account for skewness, kurtosis, heteroscedasticity, and the correlation among the irrigated and dryland cotton yield distributions.

Results indicate that the dryland cotton yields in the selected regions of Texas were right-skewed and kurtotic. If one assumes a normal distribution, it is likely that the probability of low to moderately low yields would be underestimated, while the probability of moderately high to high yields would be overestimated. Also, extremely high yields are likely to be underestimated by a normal model (Ramirez et al., 2000). If the probability of low cotton yields is being underestimated, certain crop and revenue insurance products may not appear efficient because they are not being triggered by low yields. Also, the calculation of net returns for alternative crop and revenue insurance products will be biased due to the assumption of yield distribution normality. Clearly, when comparing various crop and revenue insurance products, it is important to accurately estimate the underlying yield and price distributions used for the analyses.

In analyzing alternative crop insurance products, results suggest that the overwhelmingly preferred MPCI insurance option was the CAT option. CAT is 100 percent subsidized by the federal government and is available for only a $60 fee per crop, per county. This makes CAT a very inexpensive insurance option, and helps insure producers against disasters, hence "catastrophic" coverage. This result may indicate that all producers, regardless of mean net returns, could benefit from the purchase of CAT insurance in the long run. The 50/100 option was considered cost effective in all but a few of the scenarios studied. The 60/100 coverage level was considered cost-effective in about half of the scenarios studied. The 75/100 coverage level was never found to be cost effective. CRC 50 was considered to be cost-effective in most cases, CRC 60 was cost-effective in only two scenarios, and CRC 75 was never found to be cost effective. These results confirm that premium rates for most buy-up crop insurance alternatives are too high.

High premium rates discourage producer participation in crop insurance programs, exposing them to higher levels of financial risk. Further, during times of crop failure, the intervention of the federal government in terms of disaster payments and emergency assistance programs become necessary. Thus, actuarially fair premiums should not only result in increased producer participation, but may also decrease government expenditures.

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Table 1. Ranking of Alternative Crop Insurance Products of Irrigated Cotton According to Mean Net Returns.

	Irrigated	
	MPCI	**CRC**
SHP	CAT	No Ins.
	No Ins.	50
	50/100	60
	60/100	75
	75/100	
NHP	CAT	50
	50/100	No Ins.
	60/100	60
	No Ins.	75
	75/100	
NLP	CAT	60
	50/100	50
	60/100	No Ins.
	No Ins.	75
	75/100	

Table 2. Ranking of Alternative Crop Insurance Products of Dryland Cotton According to Mean Net Returns.

	Dryland	
	MPCI	**CRC**
SHP	CAT	50
	50/100	No Ins.
	60/100	60
	No Ins.	75
	75/100	
NHP	CAT	50
	50/100	60
	60/100	No Ins.
	No Ins.	75
	75/100	
NLP	CAT	60
	50/100	50
	60/100	No Ins.
	No Ins.	75
	75/100	

Table 3. Ranking of Alternative Crop Insurance Products of Irrigated Cotton According to Stochastic Dominance.

	Irrigated	
	MPCI	CRC
SHP	CAT	No Ins.
	No Ins.	50
	50/100	60
	60/100	75
	75/100	
NHP	CAT	50
	50/100	No Ins.
	60/100	60
	No Ins.	75
	75/100	
NLP	CAT	No Ins.
	No Ins.	50
	50/100	60
	60/100	75
	75/100	

Table 4. Ranking of Alternative Crop Insurance Products of Dryland Cotton According to Stochastic Dominance.

	Dryland	
	MPCI	CRC
SHP	CAT	50
	50/100	No Ins.
	60/100	60
	No Ins.	75
	75/100	
NHP	CAT	50
	50/100	60
	60/100	No Ins.
	No Ins.	75
	75/100	
NLP	CAT	50
	50/100	No Ins.
	60/100	60
	No Ins.	75
	75/100	

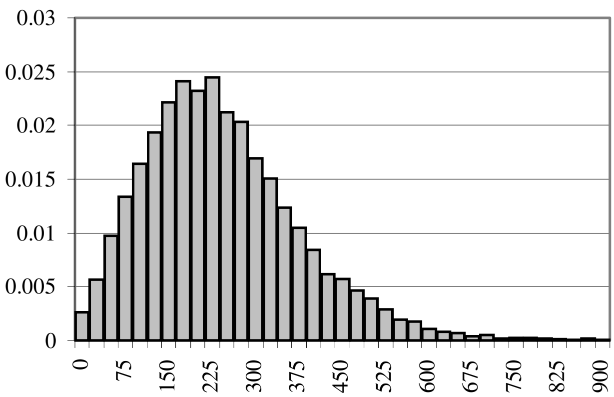

Figure 1. County Level Dryland Cotton Yield Distribution for Southern High Plains.

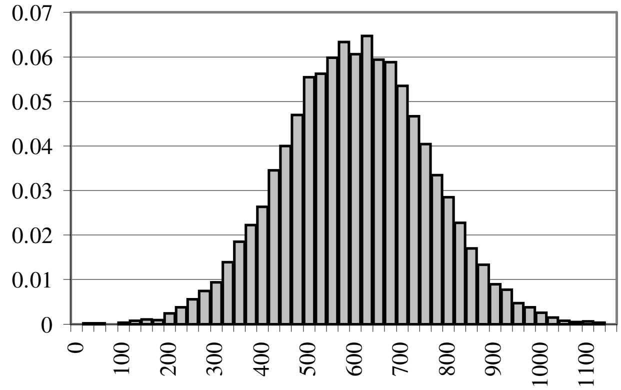

Figure 2. County Level Irrigated Cotton Yield Distribution for Southern High Plains.

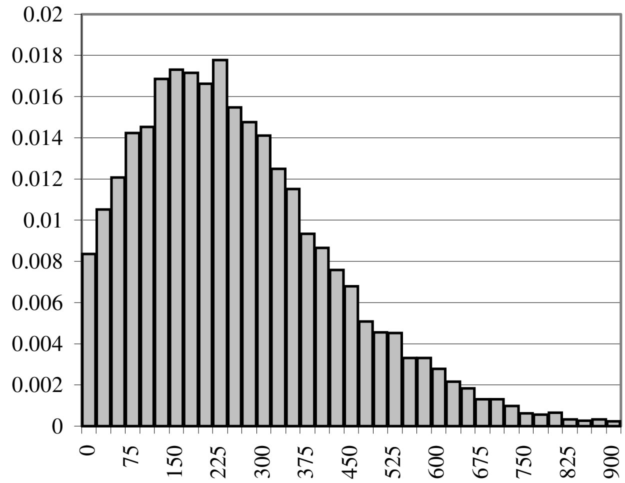

Figure 3. Farm Level Dryland Cotton Yield Distribution for Southern High Plains.

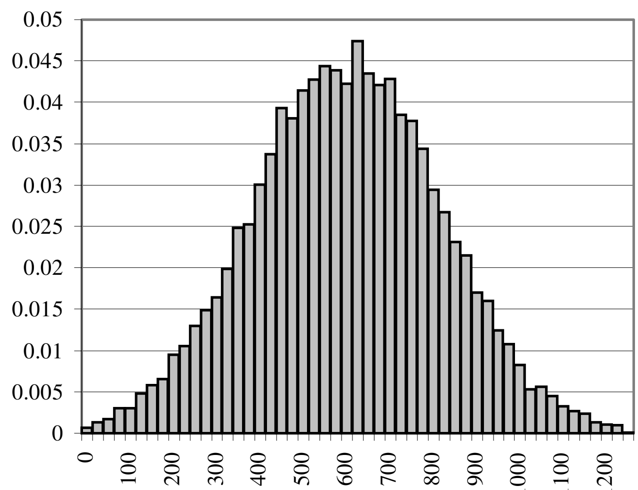

Figure 4. Farm Level Irrigated Cotton Yield for Southern High Plains.