INPUT USE, YIELDS, AND QUALITY OF COTTON IN THE TEXAS HIGH PLAINS

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Abstract

This study developed six response functions relating cotton output in terms of lint yield, seed yield, turnout, and quality attributes to input use choices and management practices employed in the production process. The estimated response functions allowed for examination of the effect of varying factors of production within the control of producers such as water and phosphorus application rates, fertilizer application methods, and variety selection on output levels, while taking into consideration different prototypical weather scenarios.

Introduction

Cotton production for the Texas High Plains varies from one season to the next. A host of factors including weather conditions, irrigation water rates, fertilization methods and rates, and variety selection affect farm-level yields and quality. Collectively, factors of production need to be managed in order to decrease the level of uncertainty associated with the production process and to increase profits through the identification of input use strategies that either reduce the cost of production, increase total output, or both.

In the past, a common strategy for increasing profits has been to improve yields by expanding input use (Bennett, 1999). However, enhancing cotton yields through this strategy might result in higher per-acre costs of production and, therefore, impede the attainment of increased profits. Furthermore, focusing on increasing only cotton lint yield might produce lower lint quality. Because cotton producers receive price premiums or discounts according to quality, a producer interested in enhancing profits needs to understand the effect of genetics, management practices, and input use on output in terms of quantity and quality. As a result, the key to increased profits is not necessarily to increase yields at any cost, but to select crop management strategies and input-use levels wisely.

Previous studies have established relationships between various factors of production and cotton output, but few have addressed the relationships between input use and quality. Green et al. (1999) compared the response of cotton yield to water supply, fertilizer application method, and nitrogen to phosphorus application ratio. The study found that lint yields increased as water application increased. A nitrogen to phosphorus ratio of 5:3 produced the highest average lint yields and fertigation proved to be an effective phosphorus application method. Morrow and Krieg (1990) clarified the importance of timing in nutrient application for improving lint yields. The study revealed that water supply during the fruiting season is more important to the determination of cotton yield than water availability prior to fruiting and that pre-plant nitrogen availability influences the response of lint yield to water supply. Stokes (1969) used regression analysis to develop a series of equations to estimate the relationships between both cotton yield and lint quality characteristics and selected managerial decisions. The study found that cotton yield on the Texas South Plains was mainly a function of planting date, irrigation in the month of August, and the amount of nitrogen applied per acre. The study also established that certain quality characteristics such as micronaire and strength are to some extent a function of variety selection. Segarra and Gannaway (1994) concluded that variety selection is an important determinant of lint yield.

Despite previous research, information and understanding about the effect of input use and management choices on cotton yield and lint quality characteristics is limited. The possibility of agronomic tradeoffs between the quantity and quality of cotton produced and the potential existence of interactions between factors of production generates a need for comprehensive evaluation of the effect of multiple factors of production on cotton output in terms of both quantity and quality. This study develops six response functions to simultaneously estimate the relationships between cotton output (lint and seed yield, micronaire, strength, staple, and turnout) and critical factors of cotton production.

Methods and Procedures

Data Description

Field experiments conducted by the Texas Tech University Plant and Soil Science Department at the Crop Production Research Laboratory in Terry County, Texas, provided the data for this study. The experiments were repeated in 1997 and 1998 and involved three replicates that received varying rates of supplemental water and fertilizer. Irrigation was provided through a LEPA system. In 1997, the experimental plots received significant rainfall (11.2 inches) during the growing season and a below average amount of heat units (2249F). In 1998, an extremely dry year, the plots received much less rainfall (5.4 inches) and an above average amount of heat units (2922F). In the experiments, applications of fertilizer involved variation of the nitrogen to phosphorus ratio (5:0, 5:1, 5:2, and 5:3). Nitrogen was applied at a constant concentration of 100 pounds per acre. Phosphorus was applied directly to the soil at varied rates ranging from 0 to 60 pounds per acre, depending upon the application method. Four different phosphorus application methods were utilized: control, pre-plant, side-dress, and fertigation. All water and phosphorus application combinations were repeated for eleven cottonseed varieties: Paymaster HS 26, Paymaster HS 200, Delta Pine 2156, Paymaster Tejas, HOL 101, HOL 338, All-Tex Atlas, AFD Explorer, AFD Rocket, All-Tex Toppick, and All-Tex Xpress. Cotton yields in 1997 and 1998 were measured for each experimental plot by hand harvesting all cotton bolls within a sample of 1/1000 of an acre. Harvested bolls were ginned at a plot gin. A sample of the ginned cotton from each plot was sent to the International Textile Center at Texas Tech University to determine the values of lint quality attributes. Staple, strength, and micronaire were measured using High Volume Instrument (HVI) tests.

The Models

In this study, six response functions were estimated using seemingly unrelated least squares (LS) regression procedures. The dependent variables were lint yield, seed yield, strength, staple, micronaire, and turnout. Each model was initially specified to include 56 independent variables with the significance of each individual model parameter evaluated using a two-tailed t-test. When necessary, F-tests were used to assess the statistical significance of groups of parameters. The results from t- and F-tests were used to determine which independent variables should be included or excluded from each of the six estimated models. The coefficients of multiple determination (R^2) for each of the models were used to assess the proportion of the observed variation in a dependent variable explained by the set of independent variables included in each of the different response functions. The following equation represents the initial model specification for the six functions:

$$
\begin{aligned}
&Y= \beta_0+ \beta_1(\text{DY2})+\beta_2(\text{DREP2})+ \beta_3(\text{DREP3})+ \beta_4(\text{WAT})+ \beta_5(\text{FA2})+ \beta_6(\text{FA3})+\\
&\beta_7(\text{FA4})+ \beta_8(\text{TPH})+ \beta_9(\text{V2})+ \beta_{10}(\text{V3})+ \beta_{11}(\text{V4})+ \beta_{12}(\text{V5})+ \beta_{13}(\text{V6})+ \beta_{14}(\text{V7})+\\
&\beta_{15}(\text{V8})+ \beta_{16}(\text{V9})+ \beta_{17}(\text{V10})+ \beta_{18}(\text{V11})+ \beta_{19}(\text{DY2TPH})+ \beta_{20}(\text{DREP2TPH})+\\
&\beta_{21}(\text{V2TPH})+ \beta_{22}(\text{V3TPH})+ \beta_{23}(\text{V4TPH})+ \beta_{24}(\text{V5TPH})+ \beta_{25}(\text{V6TPH})+\\
&\beta_{26}(\text{V7TPH})+ \beta_{27}(\text{V8TPH})+ \beta_{28}(\text{V9TPH})+ \beta_{29}(\text{V10TPH})+ \beta_{20}(\text{V11TPH})+\\
&\beta_{31}(\text{DY2WAT})+ \beta_{32}(\text{DREP2WAT})+ \beta_{33}(\text{DREP3WAT})+ \beta_{34}(\text{FA2WAT})+\\
&\beta_{35}(\text{FA3WAT})+ \beta_{36}(\text{FA4WAT})+ \beta_{37}(\text{DREP3TPH})+ \beta_{38}(\text{V2WAT})+ \beta_{39}(\text{V3WAT})+\\
&\beta_{40}(\text{V4WAT})+ \beta_{41}(\text{V5WAT})+ \beta_{42}(\text{V6WAT})+ \beta_{43}(\text{V7WAT})+ \beta_{44}(\text{V8WAT})+\\
&\beta_{45}(\text{V9WAT})+ \beta_{46}(\text{V10WAT})+ \beta_{47}(\text{V11WAT})+ \beta_{48}(\text{TPHWAT})+ \beta_{49}(\text{TPH}^2)+\\
&\beta_{50}(\text{WAT}^2)+ \beta_{51}(\text{TPH}^3)+ \beta_{52}(\text{FA2TPH})+ \beta_{53}(\text{FA3TPH})+ \beta_{54}(\text{FA4TPH})+\\
&\beta_{55}(\text{DY2TPHWAT})+ \varepsilon
\end{aligned}
$$

where:

Y = output (lint yield, seed yield, micronaire, strength, staple, or turnout)
DY2 = dummy variable representing 1998
DREP2 = dummy variable representing replicate 2
DREP3 = dummy variable representing replicate 3
WAT= irrigation water in acre-inches
TPH= phosphorus applied in pounds per acre
FA2= dummy variable for fertigation
FA3= dummy variable for pre-plant
FA4= dummy variable for side-dress
V2= dummy variable for Paymaster HS 200
V3= dummy variable for Delta Pine 2156
V4= dummy variable for Tejas
V5= dummy variable for HOL 101
V6= dummy variable for HOL 338
V7= dummy variable for Atlas
V8= dummy variable for Explorer
V9= dummy variable for Rocket

V10=	dummy variable for Toppick
V11=	dummy variable for Xpress
ε =	a random error term.

Qualitative variables included in the model act as dummy variables, which accept values of either zero or one depending upon the year, fertilizer application method, variety, and replicate under consideration. This specification results in different intercepts depending upon the year, fertilizer application method, variety, and replicate combination. Models also incorporate constructed variables to account for the interactions between qualitative and quantitative (WAT and TPH) independent variables, which allow for different slopes of the production surface with respect to water and phosphorus application rate, depending upon the year, fertilizer application method, and variety. For example, FA2WAT represents a constructed variable for a possible fertigation-water interaction. The inclusion of this variable in the model tests for a potential effect of fertigation on the efficiency of additional water application.

Estimated models are used to predict the values of each of the six dependent variables when independent variables assume empirically feasible combinations representing potential cotton production strategies. Predictions are made using an Excel spreadsheet to calculate the numerous output forecasts obtained when the values of quantitative and qualitative variables are changed. The levels of water and phosphorus evaluated by the experimental data used in this study frame the examination of the six dependent variables. For 1997, irrigation water applied when pre-plant or side-dress application methods were used ranges from 3 to 8 inches, whereas in 1998 irrigation water had values from 6 to 14 inches for these methods. Phosphorus ranges from 0 to 40 pounds per acre for both years evaluated using pre-plant or side-dress application procedures. With fertigation, irrigation water and total phosphorus applied per acre assume only values representative of the nitrogen to phosphorus ratios evaluated in the experiments.

Results and Discussion

Parameter Results

Table I summarizes the parameter estimates and related statistics for lint yield, seed yield, and turnout models. Table II provides the results for the strength, staple, and micronaire models. Superscripts indicate whether given model parameters are statistically different from zero and at which certainty level. A parameter result statistically different from zero implies that the corresponding independent variable likely affects the dependent variable under consideration. In some cases, independent variables included in the original model specification were found to share a statistically similiar relationship with the dependent variable being considered. As a result, these variables are joined in the final models. For example, All-Tex Toppick (V10) and All-Tex Xpress (V11) had an similar effects on lint yield. Therefore, these two varieties were combined to form a single variable (V1011) in the final lint yield model.

Quantitative Variable Coefficients

Within the ranges evaluated in the study, models show that irrigation water (WAT) and total phosphorus per acre (TPH) affect all six dependent variables. Irrigation water directly affects lint and seed yields in a linear fashion, meaning that lint and seed yields increase for each additional unit of irrigation water applied. The linear relationship of lint yield to irrigation water found in this study possibly results from the limited upper level of water application, which can be attributed to the intense management of water resources in experiments. Conversely, irrigation water affects all quality attributes and turnout in a non-linear fashion. For quality attributes and turnout, water accepts a quadratic term (WAT2). The presence and statistical significance of a quadratic water term for these models indicates that at certain levels each additional unit of irrigation water applied may not increase quality attributes and turnout at an increasing rate and may even decrease the response of these variables. Models also include non-linear terms for total phosphorus applied per acre (TPH). In fact, total phosphorus applied per acre shows a non-linear, second-degree polynomial effect, on lint and seed yields, as represented by the presence of the quadratic phosphorus term (TPH2) in these models. For strength, staple, micronaire, and turnout, models identify a typical neo-classical polynomial effect or a third-degree polynomial effect (TPH3).

Qualitative Variable Coefficients

Estimated models indicate that a prevailing weather scenario, specifically rainfall and heat units during the growing season, affects lint and seed yields, all quality attributes, and turnout. The weather effect is introduced through DY2, a dummy variable that equals zero during the wet year of 1997 and one during the hot, dry year of 1998. Without consideration of water or phosphorus application, lint yield, seed yield, micronaire, and turnout are lower in a hot, dry year, whereas staple and strength are higher.

Genetics (i.e. variety selection) also play a role in determining response levels of the six dependent variables. Variety intercept-shifters included in the estimated models (i.e. V3, V1011, V68, etc.) indicate that when water and phosphorus are not considered, some varieties responded better than other varieties in terms of yield and quality. Specifically, All-Tex Toppick and All-Tex Xpress produced substantially higher lint and seed yields than other varieties evaluated. All-Tex Toppick also had the highest staple and turnout values. All-Tex Xpress, together with Paymaster Tejas, produced the second highest turnout under the same circumstances. In contrast, Paymaster HS 26 produced a substantially higher “baseline” fiber strength than all other varieties considered in this study, with Delta Pine 2156 rendering the lowest fiber strength. Delta Pine 2156 also produced the shortest staple length. Paymaster Tejas, which produced the second shortest staple length, had the highest micronaire values, followed by Paymaster HS 26, Delta Pine 2156, All-Tex Atlas, and AFD Explorer. All-Tex Toppick and All-Tex Explorer produced intermediate micronaire values, while Paymaster HS 200, HOL 101, and AFD Rocket had the lowest micronaire results.

Constructed Variable Coefficients

Interaction effects between water and phosphorus (TPHWAT) occur in four of the six models. A negative total phosphorus-water interaction exists for lint and seed yields, micronaire, and turnout during both a moist, wet year and a hot, dry year. A negative interaction between water and phosphorus indicates that water is less effective on increasing yields, micronaire, and turnout at higher levels of phosphorus use. Furthermore, phosphorus is less effective at increasing the aforementioned dependent variables at higher levels of water use. This negative interaction effect is always less in the hot, dry year than in the wet year, as shown by the positive coefficient for DY2TPHWAT. In the case of staple and strength, no phosphorus-water interaction effects were detected.

Year-water (DY2WAT) and year-phosphorus (DY2TPH) interactions point to a relationship between the prevailing weather scenario and the effectiveness of applying additional units of irrigation water and phosphorus. The rate of change in lint yield, seed yield, staple, micronaire, and turnout caused by the application of additional amounts of irrigation water is different depending upon the weather scenario. In a hot, dry year, lint yield, seed yield, micronaire, and turnout increase at a faster rate when additional amounts of irrigation water are applied, given the positive sign on the DY2WAT variable for these models. Likewise, a faster rate of change for micronaire and turnout occurs in the hot, dry year when additional units of phosphorus per acre are applied. Hence, a positive DY2TPH variable is present in the models for micronaire and turnout. However, the rate of change in lint yield, seed yield, strength, and staple caused when additional amounts of phosphorus are applied per acre is lower in the hot, dry year than in the moist, wet year, as denoted by a negative sign for DY2TPH.

Variety-water (i.e.V56WAT, V29WAT, etc.) and variety-phosphorus interactions (i.e. V56TPH, V89TPH, etc.) indicated that many of the varieties evaluated respond differently to varying the rate of irrigation water use and phosphorus application. For example, Paymaster HS 26, Delta Pine 2156, Paymaster Tejas, All-Tex Atlas, and AFD Explorer had the same rate of lint yield response to irrigation water. In comparison to the former (baseline) varieties, Paymaster HS 200 and AFD Rocket showed a moderately lower rate of lint yield response to the application of additional units of irrigation water, as indicated by the negative coefficient for the V29WAT interaction. HOL 101, HOL 338, All-Tex Toppick, and All-Tex Xpress had a substantially lower lint yield response to additional water application. The coefficient (V51011WAT) representing the interaction between these varieties and water had the greatest negative value. In contrast, HOL 101 and HOL 338 had the highest level of lint yield response to additional phosphorus application. Though at a substantially lower rate, AFD Explorer, AFD Rocket, and All-Tex Xpress also improved lint yield response to additional application of phosphorus. These results are indicted by the positive value of variety-phosphorus interactions in the lint yield model.

Different groups of varieties showed different seed yield, quality, and turnout responses to irrigation water use and phosphorus application. In fact, the varieties with the highest rate of lint yield response to irrigation water use and phosphorus application were the same as those with the highest rate of seed yield response. However, even though a given group of varieties might exhibit relatively high lint and seed yield responses, all or some of the varieties may provide relatively low or undesirable quality responses to irrigation water use or phosphorus application. For example, Paymaster HS 26, which produced a high lint and seed yield response to additional units of irrigation water, had the lowest strength and staple response rates.

Fertilizer application method-water interactions (FA2WAT, FA3WAT, and FA4WAT) indicated that fertilizer application methods, in terms of lint and seed yields, were superior to the control if the minimum amount of water evaluated in the experiment is applied. In the case of lint and seed yields, fertigation and pre-plant were superior to side-dress in the sense that an additional amount of water produced higher incremental changes in yields when using either fertigation or pre-plant. Fertigation also produces the highest micronaire response to additional units of irrigation water. However, fertigation produces the lowest strength and turnout responses.

Using Estimated Models to Predict Outcomes

Tables III, IV, V, VI, VII and VIII contain the results of mathematical exercises conducted in Microsoft Excel to identify lint yield, seed yield, strength, staple, micronaire, and turnout predictions associated with different fertilizer application methods and irrigation water rates. The tables provide predictions for Paymaster HS 26, which represents the most commonly used variety on the Texas High Plains. For all predictions included in the tables, total phosphorus applied per acre is held constant at a level of 40 pounds.

The predictions contained in Tables III, IV, and VI indicated that the maximum lint yields, seed yields, and staple response possible within the range considered by this study occurred at the highest water application level for both a wet year and a hot, dry year. Overall, the highest lint and seed yield levels, shown in Table III and Table IV, respectively, occurred when either fertigation or pre-plant were selected as the fertilizer application method. For staple, Table VI shows that all fertilizer application methods produced the same effect among a given irrigation water level. In contrast, Tables V and VIII indicate that strength and turnout reached maximum levels at the lowest water application rate for both weather scenarios. Furthermore, side-dress produced the maximum strength value and pre-plant generated the highest level of turnout. All predictions pertaining to micronaire fell within the range of 3.5 to 4.9 regardless of fertilizer application method, weather scenario, or irrigation water rate.

The differences in input usage and application methods predicted to produce the most favorable levels of each of the six dependent variables substantiate the existence of agronomic tradeoffs in the production process. Quite possibly, the predicted input use combinations associated with maximum levels of lint yield, seed yield, strength, staple, and turnout are not the optimum combinations to apply. For example, the predicted input combination to maximize lint yield recommended applying irrigation water at the highest rate. However, the most favorable levels of strength and turnout occurred at the lowest water application rate. Furthermore, based upon predictions, side-dress produced the maximum strength level, but in practice this fertilizer application method has been found to reduce yield results due to root pruning. Obviously, a definitive recommendation as to the optimum combination of multiple input to use in the production process depends upon the economic assessment of the relative value of each dependent variable evaluated by this study.

Summary and Conclusions

This study developed six response functions to explain variation in cotton output associated with the selection and simultaneous use of multiple factors of production. The response functions included qualitative variables such as year, fertilizer application method, and variety selection to account for the effects of categorical changes on output levels. Among dependent variables chosen for the estimations, this study examined the existence of relationships between factors of production and quality attributes such as micronaire, staple, and strength. Original model estimations included 56 independent variables. Final models included only variables found to be statistically significant based upon the student t-test or F-test results. Final models were used to predict various outcomes given empirically feasible levels of input use.

Estimated models indicated that management practices involving the selection of fertilizer application methods and rates, as well as irrigation water rates, effected quality characteristics. Furthermore, statistical and mathematical exercises employed within the study pointed toward the existence of agronomic tradeoffs between yields and quality characteristics. Recognition of these tradeoffs is an important preliminary step to selecting production strategies to maximize profits. However, isolating the most profitable levels of variable inputs to use in the production process requires economic analysis using the estimated functions derived in this study, as well as lint prices, quality premiums and discounts, unit factor costs, and ginning costs assessed per unit of clean, marketable lint produced.

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Table I: Independent Variables, Parameter Estimates, and t-ratios for Lint Yield, Seed Yield, and Turnout Models

	Dependent Variables					
	Lint Yield		Seed Yield		Turnout	
Independent Variables	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
INT	445.68**	9.751	709.10**	9.337	26.95**	127.74
DY2	-102.88 *	-2.065	-190.28 *	-2.318	-2.90**	-12.64
DREP23	24.05 *	2.367	NA	NA	NA	NA
DREP2	NA	NA	NA	NA	0.477 *	1.77
DREP3	NA	NA	33.67 *	1.961	NA	NA
WATER	34.004**	4.16	59.74**	4.354	NA	NA
FA2	NA	NA	NA	NA	-0.644**	-2.62
FA4	NA	NA	NA	NA	-1.32**	-7.21
FA234	-104.98**	-2.704	-205.92**	-3.167	NA	NA
V28	NA	NA	NA	NA	0.223 *	1.52
V367	NA	NA	NA	NA	0.978**	5.22
V411	NA	NA	NA	NA	1.66**	10.49
V6	NA	NA	-38.80 *	-1.671	NA	NA
V10	NA	NA	NA	NA	2.43**	7.55
V1011	227.16**	9.318	303.94**	7.033	NA	NA
DY2TPH	-6.88**	-3.188	-10.69**	-2.991	NA	NA
V2711TPH	NA	NA	1.49**	4.882	NA	NA
V38911TPH	NA	NA	NA	NA	-0.036**	-6.02
V56TPH	5.06**	6.128	7.68**	5.376	NA	NA
V710TPH	NA	NA	NA	NA	-0.040**	-5.26
V89TPH	NA	NA	2.99**	4.94	NA	NA
V8911TPH	0.865**	2.874	NA	NA	NA	NA
DY2WAT	14.45 *	1.794	17.87 *	1.324	NA	NA
DREP23WAT	-3.92**	-3.211	NA	NA	NA	NA
DREP2WAT	NA	NA	NA	NA	-0.066 *	-2.03
DREP3WAT	NA	NA	-6.61**	-3.182	0.035 *	2.25
FA2WAT	NA	NA	NA	NA	0.245**	4.51
FA23WAT	42.05**	6.572	72.45**	6.914	NA	NA
FA34WAT	NA	NA	NA	NA	0.341**	6.88
FA4WAT	27.46**	4.06	50.45**	4.543	NA	NA
V245610WAT	NA	NA	NA	NA	-0.131**	-7.30
V29WAT	-4.42**	-7.544	NA	NA	NA	NA
V3WAT	NA	NA	NA	NA	0.193**	4.04
V4WAT	NA	NA	2.68 *	2.115	NA	NA
V56WAT	NA	NA	-21.56**	-5.19	NA	NA
V51011WAT	-19.87**	-8.064	NA	NA	NA	NA
V1011WAT	NA	NA	-28.61**	-6.35	NA	NA
V6WAT	-17.62**	-6.72	NA	NA	NA	NA
TPH2	0.161**	4.332	0.250**	4.209	0.006**	8.14
TPH3	NA	NA	NA	NA	-0.00004**	-5.55
WAT2	NA	NA	NA	NA	0.008**	3.84
TPHWAT	-1.13**	-3.28	-1.89**	-3.395	-0.030**	-7.65
DY2TPHWAT	0.566 *	2.138	0.878 *	2.017	0.014**	9.27
R-squared Values	0.684		0.701		0.495	

Note: Models were estimated based upon a data set comprised of 637 observations.

* statistically significant at the 5% level

** statistically significant at the 1% level

Table II: Independent Variables, Parameter Estimates, and t-ratios for Strength, Staple, and Micronaire Models

	Dependent Variables					
	Strength		Staple		Micronaire	
Independent Variables	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio	Parameter Estimate	t-ratio
INT	33.29**	44.475	1.06**	108.603	3.40**	22.652
DY2	2.79**	6.435	0.027 *	1.593	-0.293**	-3.438
DREP2	-0.405 *	-1.468	NA	NA	NA	NA
DREP3	-0.890 *	-2.35	-0.005 *	-2.108	NA	NA
WATER	-0.652**	-3.676	-0.004 *	-1.626	0.106**	2.66
FA234	NA	NA	-0.013 *	-1.181	0.766**	4.503
FA3	-0.642 *	-2.473	NA	NA	NA	NA
TPH	0.134**	3.367	0.002 *	2.019	-0.067**	-3.957
V2478	-2.73**	-5.488	NA	NA	NA	NA
V25	NA	NA	0.029**	6.346	NA	NA
V29	NA	NA	NA	NA	-0.272**	-5.725
V3	-6.55**	-11.957	-0.066**	-10.782	NA	NA
V4	NA	NA	-0.047**	-10.516	0.477**	5.886
V5	NA	NA	NA	NA	-0.318**	-4.932
V5691011	-3.29**	-6.161	NA	NA	NA	NA
V68	NA	NA	0.012**	2.771	NA	NA
V10	NA	NA	0.061**	8.009	NA	NA
V1011	NA	NA	NA	NA	-0.159 *	-2.421
DY2TPH	-0.048**	-3.706	-0.0002 *	-1.554	NA	NA
DREP2TPH	0.016 *	1.672	NA	NA	NA	NA
V2TPH	NA	NA	-0.0004 *	-2.512	NA	NA
V2910TPH	-0.025 *	-2.508	NA	NA	NA	NA
V4TPH	0.040**	2.661	NA	NA	-0.005 *	-1.97
V67TPH	-0.017 *	-1.475	NA	NA	NA	NA
V68TPH	NA	NA	NA	NA	0.008**	3.764
V811TPH	-0.066**	-4.908	NA	NA	NA	NA
V9TPH	NA	NA	0.0008**	4.589	NA	NA
DREP3WAT	0.097 *	2.177	NA	NA	NA	NA
FA2WAT	-0.118**	-4.716	NA	NA	0.039**	7.166
FA3WAT	NA	NA	NA	NA	0.018**	2.869
DY2WAT	NA	NA	-0.004 *	-1.702	NA	NA
V2310WAT	NA	NA	0.007**	8.442	NA	NA
V24811WAT	NA	NA	NA	NA	-0.022**	-3.868
V21011WAT	0.541**	7.993	NA	NA	NA	NA
V411WAT	NA	NA	0.004**	8.299	NA	NA
V37WAT	0.319**	4.459	NA	NA	NA	NA
V4WAT	0.114 *	1.464	NA	NA	NA	NA
V56789WAT	NA	NA	0.002**	5.301	NA	NA
V569WAT	0.431**	6.469	NA	NA	NA	NA
V610WAT	NA	NA	NA	NA	-0.050**	-6.954
V8WAT	0.488**	6.46	NA	NA	NA	NA
TPH2	-0.003 *	-2.167	-0.00008 *	-2.011	0.003**	5.182
WAT2	0.016 *	1.967	0.0004 *	2.037	-0.004 *	-2.04
TPHWAT	NA	NA	NA	NA	-0.005**	-6.146
TPH3	0.00003 *	1.874	0.0000007 *	1.864	-0.00002**	-4.601
DY2TPHWAT	NA	NA	NA	NA	0.002**	5.914
R-squared Values	0.445		0.669		0.417	

Note: Models were estimated based upon a data set comprised of 637 observations.

* statistically significant at the 5% level

** statistically significant at the 1% level

Table III: Lint Yield Predictions in pounds for Paymaster HS 26 Among Different Fertilizer Application Methods at a TPH Level of 40 lbs/acre

	Irrigation Water					
	Wet Year			Hot, Dry Year		
Method	3	5	8	6	9	14
Fertigation	690.8393	752.0577	843.8853	627.0598	830.2082	1168.789
Pre-plant	690.8393	752.0577	843.8853	627.0598	830.2082	1168.789
Side-dress	647.0618	679.0952	727.1453	539.5048	698.8758	964.4941

Table IV: Seed Yield Predictions in pounds for Paymaster HS 26 Among Different Fertilizer Application Methods at a TPH Level of 40 lbs/acre

	Irrigation Water					
	Wet Year			Hot, Dry Year		
Method	3	5	8	6	9	14
Fertigation	1073.4477	1186.3415	1355.6821	942.7919	1271.1576	1818.4337
Pre-plant	1073.4477	1186.3415	1355.6821	942.7919	1271.1576	1818.4337
Side-dress	1007.4356	1076.3212	1179.6497	810.7676	1073.1511	1510.377

Table V: Strength Predictions in grams/Tex for Paymaster HS 26 Among Different Fertilizer Application Methods at a TPH Level of 40 lbs/acre

	Irrigation Water					
	Wet Year			Hot, Dry Year		
Method	3	5	8	6	9	14
Fertigation	32.916	31.6457	29.9951	31.9322	30.3836	28.4824
Pre-plant	32.6305	31.5981	30.3044	32.0036	30.8117	29.5055
Side-dress	33.2729	32.2405	30.9468	32.646	31.4543	30.1479

Table VI: Staple Predictions in inches for Paymaster HS 26 Among Different Fertilizer Application Methods at a TPH Level of 40 lbs/acre

	Irrigation Water					
	Wet Year			Hot, Dry Year		
Method	3	5	8	6	9	14
Fertigation	1.06	1.058	1.0624	1.048	1.0421	1.0516
Pre-plant	1.06	1.058	1.0624	1.048	1.0421	1.0516
Side-dress	1.06	1.058	1.0624	1.048	1.0421	1.0516

Table VII: Micronaire Predictions for Paymaster HS 26 Among Different Fertilizer Application Methods at a TPH Level of 40 lbs/acre

	Irrigation Water					
	Wet Year			Hot, Dry Year		
Method	3	5	8	6	9	14
Fertigation	4.7143	4.5121	4.148	4.7514	4.6859	4.4145
Pre-plant	4.6528	4.4097	3.9841	4.6285	4.5016	4.1278
Side-dress	4.597	4.3166	3.8352	4.5168	4.334	3.8672

Table VIII: Turnout Predictions for Paymaster HS 26 Among Different Fertilizer Application Methods at a TPH Level of 40 lbs/acre

	Irrigation Water					
	Wet Year			Hot, Dry Year		
Method	3	5	8	6	9	14
Fertigation	30.8794	29.0775	26.5035	28.6694	27.8309	26.7769
Pre-plant	31.8111	30.2007	27.9139	29.88835	29.3371	28.7619
Side-dress	30.4885	28.8781	26.5913	28.5657	28.0145	27.4392