MULTIDIMENSIONAL QUALITY ATTRIBUTES AND INPUT USE IN COTTON

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Abstract

This paper uses an ordered logit model to examine the relationship between lint attributes and water and nitrogen inputs in cotton production. The ordered logit model is used because lint attributes are valued by grade and best defined as ordered categorical variables. Our data were obtained from a three-year experiment in a 48-ha center pivot field in a terminated-rye conservation tillage cotton system in Lamesa, Texas. We found that irrigation can increase the chance that lint has better elongation and color but, on the other hand, reduce the chance that lint has better micronaire and length attributes. Nitrogen was found to increase the chance of improved length and degraded color in cotton lint.

Introduction

Most domestic cotton producers sell cotton on the basis of a class card, or officially, the Smith-Doxey classification system. Each producer's cotton is graded by USDA employees who examine a sample from each bale and assign values by quality attributes (USDA, 1980). A serial of number will be given to identify the quality of the cotton. For example, a value from 0 to 7 will be assigned to refer to the color characteristics of the lint. Pure white cotton would be assigned a low number, whereas yellow, gray or discolored cotton would receive higher values, with the values increasing for the less desirable colors, indicating lower quality cotton. The other quality variable, staple, signifies the length of cotton fiber in 32nds of an inch, thus staple 32 denotes a 1-inch fiber length. Micronaire is an index of fiber fineness and maturity. Micronaire values, such as 3.1, 3.8, 5.0, etc. are determined by an instrument with fineness decreasing (coarseness increasing) as the numbers rise.

Some experiments and research have found how the soil nutrient and fertilizer affect the cotton fiber attributes. Potassium (K) is an extremely important nutrient in cotton production (Cassman, 1990; Albers et al. 1993). It affects fiber properties such as micronaire, length and strength. A shortage of K reduces fiber quality and yield, and results in plants that are more susceptible to drought stress and diseases. Read et al. (2006) found that fiber length was not consistently altered by stress, suggesting that early stages of fiber development were indirectly affected by plant N. These authors also showed that N stress indirectly affected cotton growth, as N deficiency decreased fiber length, strength and micronaire primarily in flowering groups with large percentage of bolls. But Koli and Morrill (1976) proved that the major fiber properties of length, strength, and fineness were not consistently affected by the variables of N.

There has been much discussion about high micronaire values in recent years. The important question from the producer’s point of view is whether we can lower micronaire without giving up yield potential. Some individuals take the position that genetically lowered micronaire mandates reduced yield potential. While there is a theoretical relationship between micronaire and yield potential, in practice there has never been an actual relationship between the micronaire of the U.S. crop and yield. Others found that micronaire is a genetic trait, and in general (and there are a few exceptions) that the highest yielding varieties are the higher micronaire varieties. While this relationship is generally true they are not necessarily linked (Kenneth Hood,2003). The relationship between fiber length and yield is seldom mentioned, however, regression analysis of fiber length versus yield of the U.S. crop from 1975 through 2001 reveals a very strong correlation.

This paper uses an ordered logit model to examine the relationship between lint attributes and water and nitrogen inputs in cotton production. The ordered logit model is used because lint attributes are valued by grade and best defined as ordered categorical variables.

Data

The data in this paper are from a three-year experiment in a 14-ha area within a 48-ha center-pivot field in a terminated-rye (secale cereale L.) conservation tillage cotton system in Lamesa, Texas. The experimental design was randomized complete block with split plots in three replicates. Irrigation level was assigned to the main plots, and N management was assigned to the subplots (Bronson et al. 2006).

The irrigation level main plots were twenty-four 1-m rows wide and from about 500 to greater than 1000 m long rows were circular, and therefore plot lengths were unequal. The three irrigation levels were base (targeted at 75% Evapotranspiration (ET), low (targeted 10% ET below base), and high (targeted at 10% ET above base) irrigation. There were three N treatments: zero N, blanket-rate N, and variable-rate N. The N management subplots were eight rows wide.

In May of 2002 and 2003, 'Paymaster 2326 Roundup Ready' cotton was planted into glyphosate terminated rye in 1-m rows at a seeding rate of 18 kg ha-1. In May 2004, the higher-yielding 'FiberMax 989 Roundup Ready' was planted at the same seeding rate. After hand harvest each year, cotton lint quality such as color, leaf, micronaire, strength, fiber length, and elongation were determined on the hand-pulled lint samples at the Texas Tech University International Textile Center.

The descriptive statistics for input water and Nitrogen, for the acreage lint yield and the attributes are shown in table 1.

Table 1. Descriptive statistics for variables used in regression analysis

Variable	Mean	Min	Max	Variance
Water	43.98	36	53.6	25.31
Nitrogen	100.15	4.48	256	2982.34
Micronaire	4.30	2.5	5.2	0.59
Length	1.04	0.94	1.15	0.0034
Uniformity	81.42	78.8	83.5	0.68
Strength	29.98	26.5	33.7	1.21
Elongation	7.60	4.3	10.3	3.57
Rd	74.83	70.5	78.2	2.50
+b	8.77	7	10.9	0.757

Methods and Procedures

In the previously hedonic price models, some of the attributes were in category format, some of them use USDA's grades as the attributes variables. While in the inputs and quality output estimate model, the attributes output usually in continues format. As we know, cotton is graded when they are sold on the market. So the attributes in continue format maybe over detailed for market sellers and buyers. Within the same grade, although the attributes varied in a specific range, but the market treat them as the same. Table 2 show some attributes grade and the relationship between continues attributes and the category grades.

Table 2. Some fiber attributes grade

Upper Half Mean Length		Fiber Strength (1/8 in. gauge strength in grams/tex)	
Below 0.99	Short	20 and Below	Very Weak
0.99-1.10	Medium	21-25	Weak
1.11-1.26	Long	26-29	Base
Above 1.26	Extra Long	30-32	Strong
		32 and above	Very Strong
Uniformity Index		**Fiber Elongation (%)**	
Below 77	Very Low	Below 5.0	Very Low
77-79	Low	5.0-5.8	Low
80-82	Average	5.9-6.7	Average
83-85	High	6.8-7.6	High
Above 85	Very High	Above 7.6	Very High

Because lint attributes are valued by grade, we use the ordered logistic model, rather than standard linear regression models with a continuous response variable, to estimate the relationship between inputs (i.e. water and nitrogen) and these attributes. We examined all six attributes which affect the price of cotton. They are Micronaire, Length, Strength, Uniformity, Elongation and Color (determined jointly by Rd and +b). As shown in Table 3, four grades are assigned to each attribute except Elongation according to USDA's cotton classification standard, and five to Elongation.

Table 3. Measurement of lint attributes by grade

Grade	Strength	Length	Micronaire	Uniformity	Elongation	Rd	+b
1	>=31	>=1.1	<=3	>=83	>=7.6	>=76	>=10
2	29-31	1-1.1	3-4	80-83	6.8-7.6	74-76	9-10
3	26-29	0.9-1	4-5	77-80	5.9-6.8	<74	8-9
4	<26	<0.9	>5	<77	5-5.9		<8
5					<5		

The ordered logit model is a regression model for ordinal dependent variables. It can be thought of as an extension of the logistic regression model for dichotomous dependent variables, allowing for more than two (ordered) response categories. Consider a lint attribute whose values are divided into k=0,…,k ordered categories. Denote by pk the probability that the measured value of this attribute falls into category k. The ordered probit model consists of k -1 equations as follows:

$$Logit(p_1) = \log \frac{p_1}{1-p_1} = \alpha_1 + \beta' x$$
$$Logit(p_1 + p_2) = \log \frac{p_1 + p_2}{1 - p_1 - p_2} = \alpha_2 + \beta' x$$
$$Logit(p_1 + p_2 + \cdots + p_k) = \log \frac{p_1 + p_2 + \cdots + p_k}{1 - p_1 - p_2 - \cdots - p_k} = \alpha_k + \beta' x$$

The model above is called the proportional-odds model, a special case of the ordered logit model, as the odds ratio of the event is independent of the category (parameters β are invariant across all equations above.) A positive coefficient indicates that a higher value on the independent variable will increase the chance that the attribute moves to the grade or groups of grades in question.

Results and Discussion

Using the SAS LOGISTIC procedure, we ran the above regression for all seven attribute variables in Table 3. Water was found statistically significant at the 1% level in the models of micronaire, elongation, length, Rd and plus-b, but insignificant in the models of strength and uniformity. The marginal effect of increased water on the odds ratios are reported in Table 4. If the marginal effect is greater (less) than 1, an increase in water application will increase the chance of the lint attribute being in a higher grade. Therefore, an increase in the irrigation level can lower the fiber grade in terms of micronaire and length, but boost the fiber grade in terms of elongation and color. Figure 1 depicts the decline of the odds ratio for improved micronaire as the water level increases.

Table 4. The marginal effect of water on the odds ratios of improved attributes

	Micronaire	Elongation	Length	R_d	Plus-b
Water	0.768	1.304	0.71	1.107	1.221

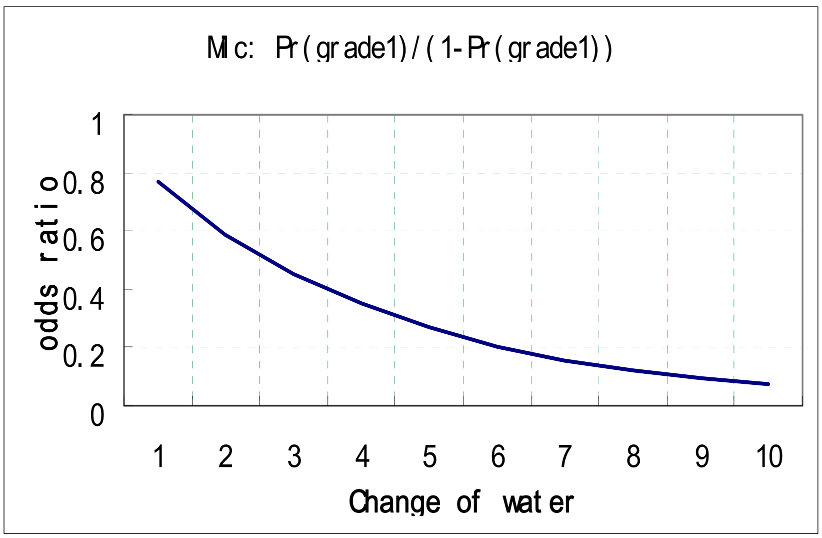

Figure 1. The odds ratio of improved micronaire declines with the water level

Results show that nitrogen is significant for length at the 5% level and for plus-b at 1% level. The corresponding odds ratios for improved attributes are reported in Table 5. In particular, nitrogen can increase the chance of producing cotton with stronger fiber, but reduce the chance of producing lint with better plus-b readings.

Table 5. The marginal effect of nitrogen on the odds ratios

	Length	Plus-b
Nitrogen	1.005	0.993

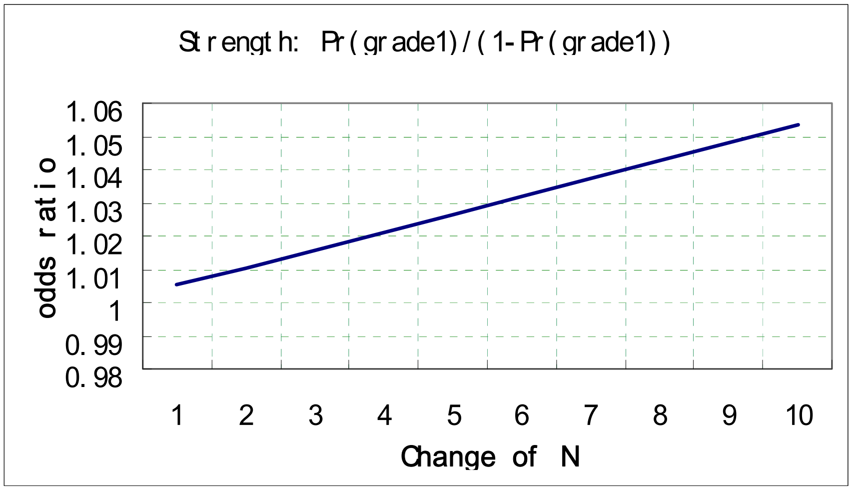

Figure 2. The odds ratio for improved strength increases with the nitrogen level

Conclusions

In conclusion, we found that irrigation can increase the chance that lint has better elongation and color but, on the other hand, reduce the chance that lint has better micronaire and length attributes. Nitrogen was found to increase the chance of improved length and degraded color in cotton lint. Future study will combine these results with previous results in hedonic price models to identify profit-maximizing input use strategies in cotton production.

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