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FACTORS IN YIELD VARIATION AMONG NORTH CAROLINA COTTON FIELDS FOR THE 2000 CROP YEAR

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Abstract

The importance of several factors of production on yield among cotton fields in North Carolina is examined. Data from 189 fields are used in the analysis. The log of yield was regressed on the log of: soil productivity, rainfall, pounds of active ingredient per acre for each of five variables, insecticide, herbicide, fungicide, growth regulator, and defoliant, pounds per acre each of nitrogen, phosphate, and potash, producer's years of experience growing cotton and transgenic cotton. Dummy variables for seed type for herbicide resistant, insect resistant, and stacked varieties were included in the regression. The coefficients for herbicide and insecticide were positive and had p-values of less than 0.05. The coefficient for growth regulator was positive and had a p-value of 0.10. None of the other coefficients, including the seed type variables, were apparently different from zero at the 10 percent level of significance.

Introduction

The purpose of this preliminary analysis is to identify variables important in explaining the variation in cotton yields among cotton fields in North Carolina. Data from the 2000 Upland Cotton Production Practices Survey for North Carolina are used in the analysis. The USDA survey was modified at the request of the investigators to include price and yield in the survey and to increase the sample size to 275 cotton fields.

Of particular interest is the possible effect of seed-type on yields and quality. Concern has been expressed by growers and others over the possible effects of the introduction of herbicide and insect resistant varieties on yield and quality. The data from the study are used to examine potential differences in yield due to seed-type and other variables for North Carolina cotton for the 2000 crop year.

Kerby et al (2000) and Hequet and Ethridge (2000) compared fiber quality of conventional to herbicide and insect resistant varieties. Both studies found only small differences in fiber quality between conventional and genetically modified varieties. Others have examined the yield characteristics of transgenic cotton lines (Cheatham, Jenkins, and McCarty, 2000). Wossink et al. (in press) examines the relative efficiency of cotton production among the fields in the survey. This study examines not only the potential impact of transgenic varieties on cotton yields, but also the potential impact of other factors that influence yield in the context of actual production practices by North Carolina cotton farmers.

Data

Data are from the USDA-NASS Agricultural Resource Management Study Upland Cotton Production Practices Report for 2000. The survey for North Carolina was modified to include information about price, yield, seed-type, variety, and equipment, as well as the regularly included inputs ranging from pesticides to producer education levels. The data are described in Bullen, Brown, and Wossink (in press). As well as including additional variables in the survey, the sample size was expanded from 40 fields to 275 fields. USDA conducts interviews with farmers to obtain the information. Removal of observations with missing values left 189 observations for use in analysis of yield variation.

North Carolina is divided into four production regions; central coastal, southern coastal, northern coastal, and southern piedmont. Four seed types were identified in the survey; herbicide resistant (Roundup Ready®), insect resistant (Bollguard®), stacked (Roundup Ready® and Bollguard®), and other (non-transgenic varieties). However, only 6 fields out of 208 were planted in insect resistant varieties. Figure 1 shows the average yield by region and seed type, excluding insect resistant varieties because of the small number of observations. Data other than seed type that are examined as explanatory variables in yield are realistic yield expectation, inches of rainfall during the growing season, pounds of active ingredient for each of five variables, insecticide, herbicide, fungicide, growth regulator, and defoliant, pounds of nitrogen, pounds of phosphate, and pounds of potash, number of years the producer has grown cotton, and number of years the producer has grown a transgenic variety. Realistic yield expectation is an index of soil productivity based on the soil type of each field and was developed by the Department of Soil Science at North Carolina State University (Hodges, 2000).

Analytical Procedures and Results

The log of yield (pounds per acre) was regressed using ordinary least squares on the log of the following variables: realistic yield expectation (the index of soil productivity), inches of rainfall during the growing season, pounds of active ingredient per acre for each of five variables, insecticide, herbicide, fungicide, growth regulator, and defoliant, pounds per acre each of nitrogen, phosphate, and potash, number of years the producer has grown cotton, and number of years the producer has grown a transgenic variety. This specification is the familiar Cobb-Douglas form (equation 1) often used in production functions.

$$Y = \Pi_i x_i^{a_i} \qquad (1)$$

Where Y is yield, the x_i are inputs, and a_i are the elasticities of yield with respect to input levels and the coefficients in the regression of the log of the variables. This is equivalent to equation 2:

$$\ln Y = \Sigma_i \; a_i \ln x_i \qquad (2)$$

Dummy variables for seed type were included in the regression. Fixed effects for each county were also included in the model. Results of the regression are shown in table 1. The regression had an R^2 of 0.42. The fixed effects for counties were statistically significant at the 1 percent level.

Among the hypothesized explanatory variables, three were statistically significant with p-values less than 0.10. Pounds of active ingredient of both insecticide and herbicide had p-values of 0.007 and 0.03, respectively. Growth regulator had a p-value of 0.08.

The p-values for the dummy variables for seed type were greater than 0.10 indicating that in the linear-in-log specification the hypothesis that the coefficient for the seed type variable equals zero could not be rejected at the 10 percent significance level. The dummy variable for herbicide resistant varieties had a p-value of 0.16, which was the smallest p-value of the three dummy variables for transgenic varieties.

Somewhat surprisingly, the index of soil productivity and rainfall also had high p-values indicating they had little explanatory power in yield variation for the 2000 crop year. None of the fertilizer variables were statistically significant, all having very high p-values. Neither the number of years the producer had produced cotton nor the number of years the producer had produced transgenic cotton were significant.

The 2000 crop year was a good year for North Carolina cotton growers and was characterized by adequate rainfall in all regions and record yields. Rainfall may not be important in explaining yield variation in the 2000 crop since it was more than adequate across all fields in the sample.

That soil productivity is not important in yield variation is surprising. There are several possible reasons for its lack of explanatory power. One possibility for the lack of explanatory power from the fertilizer variables as well as soil productivity is that when farmers optimize profits, variation in yields across fields is reduced as fertilizer is applied to offset less than optimal soil productivity. If this is the case then some multicollinearity between the soil productivity index and nitrogen, phosphate, or potash would be expected. However, no evidence of multicollinearity is present. Other possibilities are that with excellent growing conditions soil productivity is simply not very important or that the soil productivity index is not a good proxy of actual productivity.

The significance of herbicides and insecticides is not surprising and may simply indicate that insect and weed pressure and the management of insects and weeds are important, even in good growing seasons. The coefficients for the log of pounds of active ingredient of both insecticide and herbicide were positive. The coefficient for log of pounds of active ingredient of growth regulator was also significant and positive. Management of foliage growth is logically important during good growing seasons such as 2000.

In the Cobb Douglas specification, the regression coefficient gives the percent change in the dependent variable given a one percent change in an independent variable. Interpretation of the coefficients for herbicides and insecticides is not very meaningful because of aggregation across herbicides and aggregation across insecticides. The coefficient for growth regulator indicates that among cotton fields in North Carolina for 2000, a one percent increase in the pounds of active ingredient of growth regulator led to about a two percent increase in yield.

As noted, in the Cobb-Douglas specification dummy variables for seed type were not statistically significant in explaining yield variation among fields. In examining the potential influence of seed type on yield, two-sided t-tests of the mean yields among seed types also were conducted. In the tests, the data was segregated into fields planted in herbicide resistant varieties, insect resistant varieties, stacked varieties, and conventional varieties. The mean yield for fields planted in a particular seed type was compared to the mean yield for fields planted in another seed type. Specifically, the null hypotheses tested were: 1) mean yield herbicide resistant variety planted fields equal mean yield conventional variety planted fields, 2) mean yield herbicide variety resistant planted fields equal mean yield stacked variety planted fields, 3) mean yield herbicide resistant variety planted fields equal mean yield insect resistant variety planted fields, 4) mean yield stacked variety planted fields equal mean yield insect resistant variety planted fields, 5) mean yield stacked variety planted fields equal mean yield conventional resistant variety planted fields, and 6) mean yield insect resistant variety planted fields equal mean yield conventional resistant variety planted fields. In no case could the null hypothesis be rejected at the 10 percent level of significance.

Conclusions

In summary, in the linear-in-logs (Cobb Douglas) specification only three of the hypothesized production factors were found to be important in explaining yield variation among cotton fields in North Carolina for the 2000 crop year. These factors were pounds of active ingredient of herbicide, insecticide, and growth regulator. Each factor had a positive effect on yield, with each coefficient being positive. The coefficients for herbicide and insecticide had p-values of less than 0.05, while the coefficient for growth regulator had a p-value of 0.10.

In the linear-in-logs specification, seed type was not important in explaining yield variation among fields. In addition, the null hypothesis that mean yield between seed types was equal could not be rejected for any combination of seed types.

Care must be given in the application of the findings of this study. First, as noted the 2000 crop year was a very productive year for North Carolina cotton farmers. Factors having little effect on yield variation in a good growing season, could have significant effects in poor or even average growing seasons. Second, other specifications than the Cobb-Douglas should be tested.

Acknowledgements

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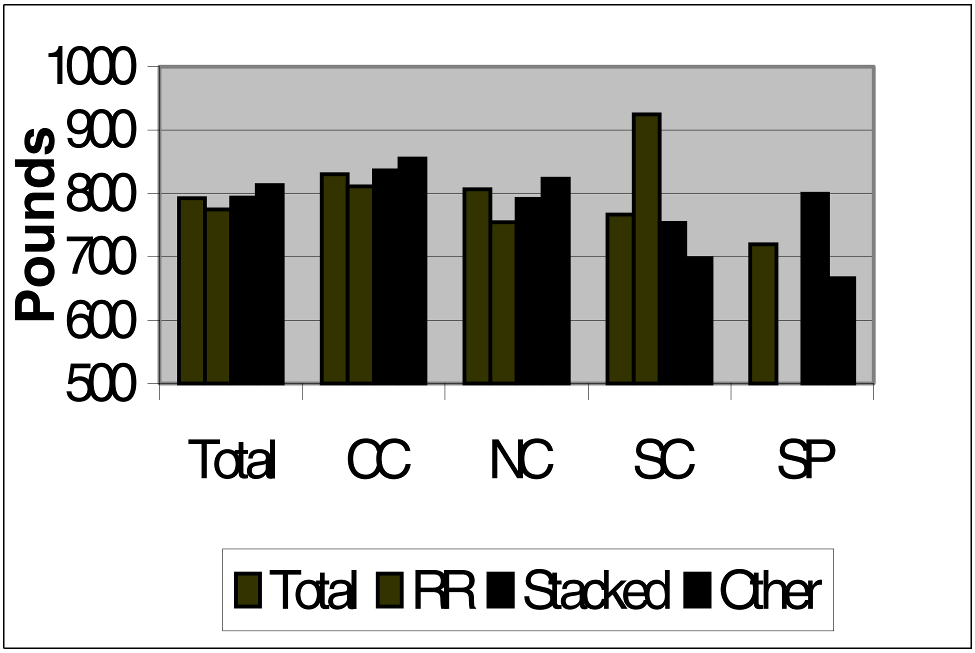

Figure 1. Mean Yield by seed type and region

Table 1. OLS results of regression of log of yield on log of factors of production

Dependent variable: log of yield/acre for individual cotton fields				**R^2 = 0.42**
Independent variable[1] (log)	**Parameter Estimate**	**Standard Error**	**t Value**	**Probability > |t|**
realistic yield expectation	0.127	0.115	1.11	0.27
rain fall	-0.183	0.232	-0.79	0.43
insecticide	0.033	0.011	2.82	0.01
herbicide	0.041	0.019	2.13	0.03
fungicide	0.012	0.027	0.44	0.66
growth regulator	0.018	0.011	1.63	0.10
defoliant	0.018	0.018	0.98	0.33
nitrogen	0.011	0.016	0.65	0.52
phosphate	-0.003	0.010	-0.28	0.78
potash	0.002	0.012	0.21	0.83
years growing cotton	0.010	0.011	0.97	0.34
years growing transgenic	0.021	0.026	0.82	0.41
herbicide resistant[2]	-0.056	0.040	-1.41	0.16
insect resistant[2]	-0.084	0.082	-1.02	0.31
stacked[2]	-0.010	0.042	-0.23	0.81

[1]Other independent variables were 33 dummies for the 34 counties for the fields in the sample. All county dummies had p-values < 0.0001.

[2]Dummy variables were assigned to indicate with which seed type a field was planted.