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An Economic Analysis of Fertilizer Use for Okra Production in Florida

Paula Foster
University of Florida

ABSTRACT

An estimated production function for okra using nitrogen and potassium fertilizer was used to examine the differences in profit under profit maximizing conditions versus output maximization. Results indicated little differences in profits and profits were relatively insensitive to changes in input prices.

Key words: Okra, fertilizer response, production function

STATEMENT OF PROBLEM

For the last two decades, okra producers have faced highly variable output prices. Associated with this, they have also faced volatile input prices, in particular fertilizer prices. In recent years, the cost of operating captial, as reflected by high interest rates, has made the cost of poor planning high. Although farmers would find it extremely difficult to respond to daily prices, they would probably find it more profitable to make production decisions at the beginning of the season that reflected the response of okra to inputs, the cost of production and price expected. Fertilizer is one of the essential input factors, especially in Florida where okra is grown on sandy, relatively nutrient poor soils.

The purpose of this study is to analyze the biological response of okra to different levels and ratios of nitrogen (N), phosphorus (P), and potassium (K) and its economic implications. To accomplish this, a production function was estimated from data collected in a Florida field trial experiment. Statistical tests were performed in order to determine the input factors which significantly affected the yield of okra. Input costs based on current fertilizer prices, and a current wholesale price for okra were used for economic analyses.

In each experiment, there were several fixed inputs, such as, the initial soil composition, weather conditions; three variable inputs, N, P, and K; and one output, okra. In the following section consideration will be given to the estimation of the production function and an evaluation of its validity. The final, main section of this paper will present an economic evaluation of the estimated production function. The economic importance of this study lies in the optimum allocation of resources to produce the profit maximizing level of output, which is not necessarily the maximum yield. The economic analyses performed include calculation

The second experiment was in the spring of 1965 (March 9). Seeds were one inch apart and fifteen harvests ran from May 12 through June 18. The average yield for this experiment was 156.08.

EMPIRICAL RESULTS

Two production functions were estimated from the empirical data described in the above experiment (Table 1). The first model was a quadratic equation including the three components of N, P, and K with all possible interactions. A quadratic form was chosen order to include stage three in the production function.

In model I, the phorphorous coefficients had signs opposite of what was expected. On an individual basis, each of these coefficients were insignificant at the 0.05 level. The results for nitrogen and potassium terms were significant and had the expected signs. In addition, the seasonal variation dummy proved to be significant. A second model was estimated eliminating all terms that contained phosphorous. A partial F-test determined that the inclusion of phosphorous in the model had no significant effect:

$$F(4,37) = \frac{(16018.15 - 14275.95)/4}{14275.95/37} = 1.13$$

The results of the second model were consistent with what is expected. The signs for N and K were positive and statistically significant at 0.05 level. The quadratic terms were negative, indicating the existence of high enough lev-

TABLE 1

Estimated parameters and associated t values.

Parameter	Estimate Model I	Estimate Model II
Intercept	196.82	199.52
	(23.12)	(26.93)
N	1.1265	1.0468
	(6.71)	(6.57)
P	-0.1817	--
	(-0.62)	
K	0.398	0.329
	(2.54)	(2.22)
NSQ	-0.0047	-0.0043
	(-4.99)	(-4.85)
PSQ	0.0033	--
	(1.13)	
KSQ	-0.0021	-0.0017
	(-2.59)	(-2.20)
NK	0.0019	0.0020
	(2.96)	(3.29)
NP	-0.00005	--
	(-0.05)	
KP	0.0003	--
	(0.23)	
Seasonal	-115.83	-112.41
	(-15.2)	(-16.00)
R-square	0.92	0.91

els of N and K to produce a maximum yield. All parameters were significant, with an overall F-ratio of 72.41, and an R-square of 0.91. The difference in weather conditions for the two years again showed significant differences in the average yield. The first experiment had exceptionally higher yeilds, indicating that factors other than fertilizer contributed to a greater amount of marketable okra. Compared to today's average yields, the estimated output in the second season, when the value of the dummy variable is equal to one, is more realistic. Therefore, a dummy variable value of one will be used for the economic analysis portion of this paper.

ECONOMIC ANALYSIS OF RESULTS

The first thing to be considered is the validity of the estimated production function. All first order conditions are met and expectations proven correct. As N and K are increased, the yield reaches a maximum and eventually declines. Over some relevant range, production experiences diminishing marginal returns to increased factor inputs; i.e. the change in output with respect to a change in input levels is negative over some range:

(1) $dY/dN = 1.0468 - 0.0086N + 0.002K$

(2) $dY/dK = 0.3292 - 0.0034K + 0.002N$

To be valid, a production function must also experience concavity over some region. This is determined by the following second-order condition:

$$f11 * f22 - f12 * f21 > 0$$

(3) $(-0.0086)\ (-0.0034) - (0.002)\ (0.002) > 0$

$$0.000025 > 0$$

The maximum yield of okra is 207.89 bushels at 195.03 pounds of K and 167.16 pounds of N. An important economic consideration is the combination of inputs which can produce a certain level of output. This isoquant relation is also derived from the production function.

(4) N = 121.72 + 0.233K + 116.28 (2.596 -

0.000025 KSQ + 0.0099 K - 0.0172 Y) ** 0.5

This equation shows how much nitrogen must be used if a certain level of output is desired, given a particular level of potassium. The slope of the isoquant represents the change in N with respect to a change in K; this is the marginal rate of technical substitution (MRTS). Currently, nitrogen costs approximately $0.32 per pound and potassium approximately $0.25 per pound. At these prices, the least cost combination can be found by equating the MRTS to the inverse price ratio for a given level of output.

Given input costs and output price, the derived demand for N and for K can also be determined.

(5) N = 167.16 - 79.41 (W1/YP) - 134.73 (W2/YP)

(6) K = 195 - 79.39 (W2/YP) - 340.73 (W1/YP)

where: YP, W1, and W2 are the prices of okra, potassium, and nitrogen, respectively.

To find the supply equation, the above expressions for N and K are substituted into the production function to find Y in terms of YP, W1 and W2.

Assumptions of a competitive market which apply to Florida okra producers include a homogeneous product and the inability of any one producer to affect product or input prices. The response to price changes in the market is shown through elasticities of demand for factor inputs as well as elasticities of profit. The profit maximizing level of output is 207.68 at 162.4 lbs. of N and 186.0 lbs. of K. Using current prices the profit maximizing level of output is virtually the same as maximum output. Input levels vary only by a few pounds. At today's prices, the price elasticity of demand for nitrogen is -0.019 and -0.017 for potassium. This indicates that profit (i.e., returns to fixed factors) is not greatly affected by changes in input prices. Using the calculated levels for maximum output and profit maximizing output, the profit levels are $2766.6 and $2770.4 per acre, respectively.

CONCLUSIONS

The marketable yield of okra in Florida is affected by the amount of nitrogen applied, the amount of potassium applied, interaction of nitrogen and potassium, and the weather conditions of the particular season. As greater amounts of fertilizer are applied, output eventually declines.

The profit maximizing level of output and maximum output for the okra producer are nearly the same due to the insensitivity of profit to changes in input prices. Decisions of how much fertilizer to use are made at planting time based on the cost of fertilizer, which has been shown to not significantly affect profit. Because the market price of okra is so volatile, production decisions are not based on its price, therefore profit sensitivity to changes in output price is irrelevant. Harvesting decisions, however, are nearly exclusively determined by output price.

On a large scale, these small changes in profit could be significant. However, in the state of Florida plating rearly occurs in 10 acres or more due to the labor-intensive nature of the harvest [Lazin, 1983]. In a 10 acre plot, the greatest difference in profit between the two output levels is only $38.00. Therefore, the decision of how much fertilizer to apply should result in production of maximum output.

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