Economic Feasibility of Kenaf Production in Three Tennessee Counties

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Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Mobile, Alabama, February 3-6, 2007

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Introduction

Kenaf is an alternative crop in the hibiscus family that may be economically feasible to produce in Tennessee. It is a fiber crop that can be harvested to make premium quality fine paper, as well as lower grade papers and cordage. Kenaf fibers have also been used to produce rope, canvas, sacking, carpet backing, fishing nets, interior automobile parts such as door panels and headliners, animal bedding, and composite lumber substitutes (EnviroLink, 1999). The stalk of the kenaf plant consists of two types of fiber, outer bast and inner core. The outer fiber, approximately 40% of the plant, is similar to the best softwood fibers used in the production of paper. The whiter inner fiber is similar to hardwood fibers in size and is also suitable for the production of paper (Johnson, 2001). Even though potential uses for kenaf have been evaluated since the early 1980's with textiles being identified as an additional potential use (Taylor, 1984), one significant challenge in the development of a kenaf market has been the pulp mill industry.

Kenaf can be grown as an alternative crop, but encouraging farmers to substitute kenaf on acreage traditionally planted in crops like corn and cotton has been slow to develop due to the lack of enterprise budget data (Scott and Taylor, 1990). The objectives of this research were: 1) to evaluate the economic feasibility of producing kenaf in Carroll, Gibson, and Madison Counties in Tennessee, and 2) to determine the kenaf price required to encourage profit-maximizing corn, cotton, wheat, and soybean growers to produce kenaf.

Methods and Procedures

Several steps were taken to examine the economic feasibility of kenaf production in the three-county area. First, after reviewing literature on kenaf production in other states, an initial cost-and-return budget was developed as a starting point. The literature review revealed substantial variation in the assumptions and recommendations for nitrogen fertilization. It also revealed that kenaf yields respond to nitrogen fertilization. Consequently, when the initial budget was modified in succeeding steps, economically optimal nitrogen rates and yields for different soil types differentiated the soil-type budgets from the initial budget.

Second, 30 different soil types suited for agricultural production were identified in the three-county area surrounding Milan, Tennessee. These counties were selected because they are close to the University of Tennessee Milan and West Tennessee Research and Education Centers where the Tennessee kenaf experiments were conducted. The 30 soils types were identified as soils with the potential for being cropped based on the National Resource Conservation Service's STATSGO database (National Resource Conservation Service, 2004). The soils identified within each Mapping Unit ID (MUID) were matched with the potential yield file. If a row-crop yield was specified in the database, the soil was assumed to have the potential to be cropped. The area for each soil was matched to the amount of land cropped in the 2002 Agricultural Census (National Agricultural Statistics Service, 2005) and areas uniformly adjusted at the county level so that the area of cropped land by soil type summed to the acres cropped in 2002 within each of the three counties. These soils were identified as the soils within the three-county region on which kenaf could potentially compete with other crops.

Third, profit-maximizing nitrogen fertilization rates and yields from kenaf meta-yield response functions were determined for each soil type using the Environmental Policy Integrated Climate model (EPIC) (Williams et al., 1989). Crop growth simulation models, such as EPIC, can be used to evaluate the relationships among crop productivity and selected environmental factors. Numerous applications of EPIC have been performed in the United States and in other regions of the world across a broad spectrum of environmental conditions. The flexibility of

EPIC has also led to its use within several integrated economic and environmental modeling systems that have been used to evaluate agricultural policies at the farm, watershed, and/or regional scales (Taylor et al., 1992; Bernardo et al., 1993; Foltz et al., 1995; Babcock et al., 1997). Other examples of crop growth simulation models are CERES (Ritchie et al., 1989) and SOYGRO (Jones et al., 1989). Many of these models were developed for particular localities and were designed to simulate the growth of a single crop. To evaluate the economic feasibility of kenaf production in Tennessee, simulations of multiple crops were required.

The meta-response functions were estimated as quadratic-plateau functions from data generated through EPIC simulations. Plateau values were considered to provide the maximum yields for each crop and soil (Cerrato and Blackmer, 1990). Kenaf yields were obtained by increasing the nitrogen rate from 0 to 340 lb/ac in 20 lb/ac increments. The yield obtained from EPIC for a given nitrogen rate and soil was the average of yields simulated over 100 years. Weather conditions were drawn at random from distributions obtained from the weather station at the University of Tennessee Milan Research and Education Center.

Fourth, the initial kenaf budget was modified for each of the 30 soil types by replacing the initial nitrogen rate and yield with the profit-maximizing rates and yields, assuming other input costs were constant across soil types. The bottom lines in these modified kenaf budgets estimated returns to land and management for the respective soil types.

Fifth, EPIC simulations similar to the ones for kenaf were used to estimate quadratic-plateau corn, cotton, soybeans, and wheat meta-nitrogen yield response functions for each soil type. No-tillage production practices were assumed and inputs other than nitrogen were as specified in existing University of Tennessee crop budgets (Gerloff, 2004a). The existing crop budgets were modified by replacing the nitrogen rates and yield in the budgets with the resulting profit-maximizing nitrogen rates and yields. Returns to land and management for each competing crop on each soil type were taken from the bottom lines of the modified budgets.

Sixth, returns to land and management were compared for kenaf, corn, cotton, wheat, and soybeans to discover which crop produced the highest return on each soil type. Because nitrogen is not a major input in soybean production, the University of Tennessee soybean budget (Gerloff, 2004a) was used for each soil type with yields adjusted by the 100-year average estimated by EPIC.

Seventh, a kenaf supply curve was mapped for the three-county area by comparing optimal kenaf production for each kenaf price between \$35/ton and \$75/ton in \$10/ton intervals. For each price, optimal kenaf production for a particular soil type was calculated as the product of its acreage and optimal yield. The potential quantity of kenaf supplied for a particular price was optimal kenaf production summed across the soil types for which kenaf was identified as the most profitable crop.

Results

Initial Cost-and-Return Budget for Kenaf Production in Tennessee

The initial 2004 kenaf budget was developed for Tennessee (Table 1) by examining the results of several projects undertaken in the southern United States. Kenaf yields and prices were the most uncertain items in the cost-and-return budgets. They varied widely among the various projects. The initial budget in Table 1 included a yield of 7.2 tons/acre, the mean yield obtained from experiments conducted in 2001 through 2003 for four varieties at the University of Tennessee Milan Research and Education Center (Milan, TN) (Brown et al., 2003). Data for the same period from experiments conducted at the University of Tennessee's West Tennessee Research and Education Center (Jackson, TN) were also examined. The mean yield from the

Milan experiments was used in the initial budget because it more closely reflected the assumptions for nitrogen fertilization found in the review of literature.

The September 2004 seed price of $3/lb (Anderson and Mullens, 2001) was used in the initial budget (Table 1) with a seeding rate of 6.6 lb/acre (Brown et al., 2003). Seed price could be reduced $1/lb if purchased in bulk (Rymsza, 2005). The higher price was used in the budget as a conservative estimate. Scott and Taylor (1990) used seeding rates of 8 lb/acre and 10 lb/acre depending on the soil. Baldwin (2004) and Kalo et al. (1999) used seeding rates of 8 lb/acre and 14 lb/acre, respectively, while Stricker et al. (2001) used a seeding rate of 10 lb/acre.

Phosphate (P_2O_5) and potash (K_2O) fertilization rates should be determined by soil testing. These fertilizers have small effects on kenaf yields compared to nitrogen fertilization (Neill et al., 1994). Nevertheless, the standard rates for Tennessee cotton production of 60 lb/acre and 90 lb/acre for P_2O_5 and K_2O (Gerloff, 2004b), respectively, were assumed to maintain soil productivity (Table 1).

The Tennessee kenaf experiments (Brown et al., 2003) were conducted on Collins (at Milan, TN) and Lexington (at Jackson, TN) silt loam soils. Nitrogen application rates were 40 lbs N/acre in 2001 through 2003 at Jackson and 40, 80, and 60 lbs N/acre at Milan in 2001, 2002, and 2003, respectively (Brown et al., 2003). In 2002, yields at Milan averaged 3.4 tons/acre higher than at Jackson, which was partly attributed to the 40 lbs N/acre higher rate (Hayes, 2004). Neill et al. (1994) recommended a rate of 150 lbs N/acre based on a literature review and experiments conducted in 1991 through 1993 at Leverette, Mississippi on a silt loam soil. In addition, Baldwin (2004) included a nitrogen rate of 96 lbs N/acre in his Mississippi kenaf budgets and Stricker et al. (2001) included 120 lbs N/acre on phosphatic clay soil and 140 lbs N/acre of on sandy soil. Scott and Taylor (1990) used 18 lbs N/acre and 100 lb N/acre in Texas, and in Colorado, Pearson (1999) pre-plant broadcasted 22 lbs N/acre. Due to the similar climate and soil characteristics in the three-county area, the initial Tennessee kenaf budget (Table 1) included a nitrogen fertilization rate of 80 lbs N/acre based on the amount applied at Milan in 2002. The custom charge of $4.00/acre for fertilizer application was obtained from Epps (2005).

A labeled herbicide is not available for no-till kenaf production in Tennessee. Treflan is the only herbicide labeled for kenaf production in Tennessee, and it is only labeled for pre-plant incorporated application. Although no herbicides are labeled for no-till kenaf production in Tennessee, weed control will be required. The kenaf budget included weed control costs to more accurately reflect costs of production (Byrd and Baughman, 2002). For kenaf production to be feasible in Tennessee, steps should be taken to secure Special Local Need 24(c) Labels for a full complement of herbicides. The herbicides used in Table 1 were taken from the University of Tennessee no-till cotton budget (Gerloff, 2004b) and from other sources described below. Generic glyphosate was included because it is increasingly used in place of Roundup as a burndown herbicide in Tennessee (Hayes, 2004). The budget included 2, 4-D to control glyphosate resistant horseweed, which is becoming more prevalent in Tennessee (Hayes, 2004). Gramoxone Max was included as a pre-emergence contact herbicide to control annual grasses and broadleaf weeds and Prowl was included to control annual grasses and some broadleaf weeds. Staple was included as a post-emergence herbicide to control pigweed and other annual broadleaf weeds. Staple has a Special Local Need 24(c) Label for North Carolina kenaf production for post-emergence control of annual broadleaf weeds. Herbicide rates came from chemical labels published by the manufacturers (Naso, 2004) and prices came from the Weed Control Manual for Tennessee (Steckel and Breeden, 2004).

The machinery used for planting and spraying chemicals included a 215 Hp tractor, a 12-row no-till planter, and a 16-row self-propelled sprayer. Total machinery cost for producing kenaf (excluding harvest cost) was calculated as the sum of fixed and variable costs for operating the machinery. Fixed machinery cost was calculated as the sum of depreciation, interest, taxes, insurance, and storage costs. Variable machinery cost was the sum of repair, fuel, oil, and filter costs. Fixed and variable machinery costs were obtained from the 2004 no-till cotton budget developed by the University of Tennessee (Gerloff, 2004b).

Machinery assumed in calculating the costs of kenaf harvesting and module building included a corn silage harvester, tractor, 2 boll buggies, 2 module builders, and tarps. A custom harvesting rate was assumed to capture the fixed and variable costs of the corn silage harvester and the labor used to operate it. A custom harvesting rate of $40/acre was assumed in 1997 (Baldwin, 2004; Kalo et al., 1999; Bowling et al., 1998) and the cost of module building was estimated at $52.52/acre in 1997 (Baldwin, 2004). Custom harvesting and module building costs were inflated to 2004 dollars by the Implicit Gross Domestic Product Price Deflator (Bureau of Economic Analysis, U.S. Department of Commerce, 2000) resulting in a custom harvesting cost of $45.37/acre and a fixed module-building machinery and tarp cost of $59.57/acre (see Table 1). Labor hours were calculated as the sum of labor used in kenaf production and module building. Harvesting labor included labor required to pull the boll buggies and create the modules but excluded labor required to operate the silage harvester, which was part of the custom harvesting charge. For production operations, labor hours for planting and application of herbicides were assumed to be 1.25 times machine hours (Gerloff, 2004b). Labor hours for module building (tractor operation to pull boll buggies and create modules) were taken from Baldwin (2004). Labor costs for production ($0.90/acre) and module building costs ($5.28/acre) were estimated using a wage rate of $8.00/hr (Gerloff, 2004b) to give a total labor cost of $6.18/acre (see Table 1). The base yield of 7.2 tons/acre and base price of $55.00/ton used in Table 1 resulted in a return to land and management of $127.49/acre.

Returns to Land and Management for Kenaf and Competing Crops

Table 2 presents the 30 soil types and their kenaf meta-yield response functions for nitrogen. At the base prices for kenaf ($55/ton) and nitrogen ($0.38/lb), economically optimal nitrogen rates ranged from 89 lb/acre for Falaya soil to 241 lb/acre on Henry soil, while optimal kenaf yields ranged from 6.3 tons/acre on Bibb soil to 11.5 tons/acre on Memphis soil. EPIC simulation predictions of nitrogen rates and yields were higher than observed farming situations due in part to the modeling assumption that inputs other than nitrogen were applied at sufficient rates to prevent yield reductions from insufficient application. When calibrating competing crops in the EPIC model, the same procedures and calibrations for each crop were made to calculate optimal nitrogen rates and yields, which allowed for direct comparisons among crops. EPIC yield responses across all comparable crops were very close to actual yields in the region. Actual yields of comparable crops in the region were 119, 36, and 35 bushels/acre with EPIC simulated yields of 109, 38, and 30 bushels/acre for corn, soybeans, and wheat respectively.

Using the meta-response functions and accounting for harvesting cost changes at a rate of $9.01/ton, the returns to land and management for yields ranging from 60 to 140 percent of optimal (Table 2) were estimated for an average of all meta-response functions and for the highest and lowest yielding soils in the region using prices from $35 to $75/ton in $10/ton increments. The harvest cost of $9.01/ton was derived from the initial budget by summing harvesting machinery costs of $59.57/acre and harvesting labor costs of $5.28/acre and dividing by the average yield of 7.20 tons/acre. At the $35/ton price level, net returns are negative for all levels of yield except when yield is 40 percent greater than the optimal yield (Table 3). At $65/ton the average meta-response function provides a positive net return over all yield ranges examined. On the highest yielding soil (Memphis), positive returns are generated at all price levels except $35/ton when yields are equal to the optimal yield level. Even when yields are 80% of the optimal yield level, net returns range from $9/acre to $281/acre when prices are $45/ton and $75/ton, respectively. However, the lowest yielding soil (Bibb) provides positive net returns under this range of prices when yield is 80% of optimal at $65/ton to a low of $45/ton when yield is 140% of optimal.

Break-even kenaf prices using the average meta-response function ranged from $63.95/ton for a yield of 60% of optimal to $33.45/ton if a yield 140% of optimal is attained. When the expected yield is achieved, the break-even price over all soils is $42.55/ton and ranges from $53.70/ton for the Bibb soil to $37.27/ton for the Memphis soil. Any price above these break-even prices would provide the farmer with a positive return to land and management.

Typically, only a portion of a farmer's land is planted to a single crop. Benefits from crop rotations occur and are not captured in this analysis. Crop diversification is used by farmers to decrease production and marketing risk; two factors that are also not captured in this analysis. While states like Iowa have counties where more than 50% of the cropland is planted in a single crop, this high percentage is not typical of Tennessee counties (National Agricultural Statistics Service, 2004).

Table 4 shows returns to land and management for kenaf and competing crops. Given the base kenaf price of $55/ton, cotton and kenaf consistently compete for the top position as the profit-maximizing crop in the three-county study area. Competing crop returns to land and management were created using 2002 – 2004 prices and costs (Gerloff, 2004a). If farmers were to produce kenaf on all soils for which it is the profit-maximizing crop, they would produce 154,930 acres of kenaf on 37% of the 423,825 acres of available cropland in the three-county area and optimal production on those acres would be 1,385,700 tons. This 37% is well within the estimated acreage for the crop with the most acreage in the three-county region.

Table 5 illustrates how optimal kenaf production changes as the farm-gate kenaf price increases from $35 to $75/ton and nitrogen price changes from $0.19 to $0.57/lb. Profit-maximizing farmers would not produce kenaf if the farm-gate kenaf price were $49/ton or less. At this price, cotton is the most profitable crop on all soil types evaluated. Alternatively, kenaf is the most profitable crop on all soil types when its price is above $67/ton. Increases in optimal kenaf production above $67/ton simply result from higher optimal nitrogen rates, which in turn result in higher optimal yields as farmers maximize profits. For price increases between $49 and $67/ton, kenaf production increases because it becomes the most profitable crop on additional soils, and nitrogen rates and yields increase in response to the maximize profit criterion.

Results in Table 5 suggest that optimal kenaf production is insensitive to changes in the nitrogen price. For example, at a kenaf price of $50/ton, a 50% reduction in the nitrogen price produces a 0.6% increase in kenaf production, and a 50% increase in the nitrogen price produces a 1.2% decrease in kenaf production. Responses to changes in the nitrogen price are even less at higher kenaf prices.

Summary, Conclusions, and Caveats

The economic feasibility of producing kenaf in three Tennessee counties was examined using budgeting, simulation, and break-even analysis under the assumption of profit-maximization. A base budget for kenaf was developed using secondary-source information along with information from three-year experiments conducted at the University of Tennessee Milan and West Tennessee Research and Education Centers. The base budget was compared to budgets for traditional crops. One-hundred-year simulations were conducted for kenaf, corn, cotton, wheat, and soybeans on 30 soil types currently cropped in the three-county area under a range of nitrogen fertilization levels (0 to 340 pounds of elemental N). Response functions for each soil type were estimated and break-even and sensitivity analyses were conducted.

At base prices for kenaf ($55/ton) and nitrogen ($0.38/lb), economically optimal nitrogen rates ranged from 89 lb/acre for Falaya soil to 241 lb/acre for Henry soil, while optimal kenaf yields ranged from 6.2 tons/acre for Bibb soil to 11.4 tons/acre for Memphis soil. Comparisons of the traditional crops with kenaf showed that cotton and kenaf consistently competed for the top position as the profit-maximizing crop for all 30 soil types in the three-county area. When the kenaf price increased above $67/ton, kenaf was the most profitable crop on all 30 soil types, but when the price fell below $49/ton, it was not the most profitable crop on any soil type. Optimal kenaf production was insensitive to changes in the price of nitrogen fertilizer.

The results of this research include the implicit assumption that marketing costs incurred by farmers for kenaf and competing crops are equal. In kenaf's competition with cotton as the most profitable crop, a higher marketing cost compared to cotton would reduce the competitive position of kenaf. For example, if the marketing cost for kenaf were $5/ton more than the marketing cost for a competing crop, a $55/ton farm-gate price would be equivalent to a $50/ton farm-gate price when comparing returns to land and management. Differences in marketing costs would change the optimal supply of kenaf and should be considered by potential kenaf producers and industrial users when making production and marketing decisions.

Implicit in the assumptions of this analysis is that farmers are profit maximizers who produce the profit-maximizing crop regardless of risk. Being a new crop without an established market and with uncertain production methods and costs compared to traditional crops, kenaf would be more risky to produce than traditional crops. In addition, farmers attempt to reduce production and marketing risk by growing crops in rotation and through diversification of crop production. The introduction of risk would reduce kenaf produced by risk averse farmers at each price compared to what is reported in Table 4. If farmers perceive that there is more risk involved in producing kenaf than the other crops, as might be the case with a new crop and market, the estimated acreage converted to kenaf production is probably high and a risk premium might be determined and employed in future analyses of kenaf production. The use of contracts and other guarantees by industrial users of kenaf would reduce the risk to farmers associated with growing kenaf and increase its supply for industrial use.

Finally, this analysis assumes that a market exists for the product grown. As indicated by Noelie Bertoniere of ARS, “Farmers won’t grow it unless they are guaranteed a market. … so it’s a chicken and egg situation” (EnviroLink, 1999).

References

Anderson, J.B., and D.B. Mullens, Jr. (2001). "KenafSeed.Com." Jupiter Seed Company and D.B.M. Farms, Inc. Online. Available at http://www.kenafseed.com/us2001pricesheet.htm. [Retrieved September 17, 2004].

Babcock, B.A., J. Wu, T. Campbell, P.W. Gassman, P.D. Mitchell, T. Otake, M. Siemers, T.M. Hurley. (1997). RAPS 1997: Agriculture and the environmental quality. Ames, IA: CARD, Iowa State University.

Baldwin, B. (2004, September 15) "Kenaf Costs and Returns Budgets for South Mississippi for 1997." Personal communication by fax.

Bernardo, D.J., H.P. Mapp, G.J. Sabbagh, S. Geleta, K.B. Watkins, R.L. Elliott, and J.F. Stone. (1993). Economic and environmental impacts of water quality protection policies 2. application to the Central High Plains. Water Res. 29(9): 3081-3091.

Byrd, J., Jr., and T. Baughman. (2002). "Kenaf Weed Control Recommendations." Mississippi State University Extension Service, Information Sheet 1528, December 3. Online. Available at http://msucares.com/pubs/infosheets/is1528.htm [Retrieved May 3, 2005].

Bowling, R. G., D. L. Hunter, R. M. Millsaps, and J. Stokes. (1998). "Farm Machinery Custom Rates by Crop Reporting Districts in Tennessee 1997." University of Tennessee Extension Service PB 1085-1M-5/98 (Rep).

Brown, B., J. Williams, J. McClure, G. Percell, and R. Hayes. (2003). "Kenaf Variety and Date of Planting Study: West Tennessee and Milan Experiment Stations, 2001-2003." Unpublished data. Tennessee Agricultural Experiment Station.

Bureau of Economic Analysis, U.S. Department of Commerce. (2000). "Table 1.1.9. Implicit Price Deflators for Gross Domestic Product [Index numbers, 2000=100] Seasonally Adjusted." Online. Available at http://www.bea.gov/bea/dn/nipaweb/TableView.asp?SelectedTable=13&FirstYear=2002&LastYear=2004&Freq=Qtr. [Retrieved February 1, 2005].

Cerrato, M.E., and A.M. Blackmer. (1990). "Comparison of models for describing corn yield response to nitrogen fertilizer." Agron. J. 82:138-143.

EnviroLink. (1999, March) "Kenaf: On the Fence." Envirolink: The Online Environmental Community. Online. Available at http://www.envirolink.org/articles/mar99-2.html. [Retrieved August 2, 2005].

Epps, B. (2005, January 28) Fertilizer Department, Tennessee Farmers Cooperative. Personal communication by telephone.

Foltz, J.C., J.G. Lee, M.A. Martin, and P.V. Preckel. (1995). "Multiattribute assessment of alternative cropping systems." Amer. J. Agr. Econ. 77: 408-420.

Gerloff, D.C. (2004a). "Field Crop Budgets for 2004." Department of Agricultural Economics, University of Tennessee Agricultural Extension Service, Information Series AE 04-29.

Gerloff, D.C. (2004b). "Cotton Budgets for 2004." Department of Agricultural Economics, University of Tennessee Agricultural Extension Service, Information Series AE 04-30.

Hayes, R.M. (2004, August 27) Superintendent of the West Tennessee Experiment Station. Personal communication by email.

Johnson, J. (2001, April) "What is Kenaf." Rural Enterprise and Alternative Development Initiative, Report No.1.

Jones, J.W., K.J. Boote, G. Hoogenboom, S.S. Jagtar, G.G. Wilkerson. (1989). *SOYGRO* V*5.42,*. Department of Agricultural Engineering and Department of Agronomy, University of Florida, Gainesville.

Kalo, A., S.B. Sterrett, P.H. Hoepner, F. Diem, and D.B. Taylor. (1999). "Feasibility of Adopting Kenaf on the Eastern Shore of Virginia." p. 311–315. In (J. Janick, ed.) *Perspectives on New Crops and New Uses*. ASHS Press, Alexandria, VA.

LeMahieu, P.J., E.S. Oplinge, and D.H. Putnam. (1991). "Alternative Field Crops Manual: Kenaf." Online. Available at http://www.hort.purdue.edu/newcrop/afcm/ kenaf.html. [Retrieved August 24, 2004].

Naso, V. (2004) "Crop Data Management Systems, Inc. Web Site." Online. Available at: http://www.cdms.net/manuf/manuf.asp. [Retrieved September 15, 2004].

National Agricultural Statistical Service. (2004). "Tennessee State and County Data." *2002 Census of Agriculture*, Vol. 1, Geographic Area Series, Part 42. U.S. Department of Agriculture.

————————. (2005) U.S. Department of Agriculture, Quick Stats: Agricultural Statistics Data Base. Online. Available at http://151.121.3.33:8080/QuickStats/. [Retreived July 29, 2005].

National Resource Conservation Service. (2004). U.S. Department of Agriculture, State Soil Geographic (STATSGO) Database. Online. Available at http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/. [Retrieved September 30, 2004].

Neill, S.W., C.H. Hovermale, and M.E. Kurtz. (1994). "Fertility and Row Spacing for Kenaf Productions." pp. 7-8. In (C.E. Goforth and M.J. Fuller, eds.) *A Summary of Kenaf Production and Product Development Research 1989-1993*. Mississippi Agricultural & Forestry Experiment Station, Mississippi State University, Bulletin 1011.

Pearson, C.H. (1999). "Economic Performance of Kenaf Varieties in the Grand Valley of Western Colorado." Online. Available at http://www.colostate.edu/programs/wcrc/annrpt/99/Kenafproceedings.htm. [Retrieved August 21, 2004].

Ritchie, J.T, U. Singh, D. Godwin, and L. Hunt. (1989). *A User's Guide to CERES – Maize V. 2.1.* International Fertilizer Development Center, Muscle Shoals.

Rymsza, T.A. (2005, July 19) President Vision Paper, Albuquerque, NM. Personal communication by email.

Scott, A.W. Jr., and C.S. Taylor. (1990). "Economics of Kenaf Production in the Lower Rio Grande Valley of Texas." p. 292-297. In (J. Janick and J.E. Simon, eds.) *Advances in New Crops*. Timber Press, Portland, OR.

Steckel, L., and G.K. Breeden. (2004). "2004 Weed Control Manual for Tennessee." University of Tennessee Extension, PB1580.

Stricker, J.A., G.M. Prine, and T.C. Riddle. (2001). "Kenaf – A Possible New Crop for Central Florida." Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, No. SS-AGE-68, February 1998 (Revised July 2001).

Taylor, C.S. (1984, May) "A Systems Approach to Commercialization of Kenaf." Unpublished Ph.D. dissertation, Department of Agricultural Economics, University of Missouri, Columbia.

Taylor, M.L., R.M. Adams, and S.F. Miller. (1992). Farm-level response to agricultural effluent control strategies: the case of the Willamette Valley. J. Agric. Resour. Econ. 17(1): 173-183.

Webber III, C.L., and R.E. Bledsoe. (1993). "Kenaf: Production, Harvesting, Processing, and Products." p. 416-421. In (J. Janick and J.E. Simon, eds.) *New Crops*. Wiley, New York.

Williams, J.R., C.A. Jones, J.R. Kiniry, and D.A. Spaniel. (1989). "The EPIC Growth Model." *Transactions of the American Society of Agricultural Engineers* 32:479-511.

Table 1. Initial No-Tillage, Farm-Gate Kenaf Budget (38-inch rows), Estimated Costs and Returns per Acre, Assuming 12/16-row Equipment.

Item	Description	Unit	Quantity	Price	Amount
Revenue				Dollars ($)	
Kenaf	Stalks	Ton	7.20	$55.00	$396.00
Variable Expenses					
Seed	8.5 seed/ft	Lb	6.6	$3.00	$19.80
Fertilizer					
N (as AN)		Lb	80	$0.38	$30.40
P_2O_5		Lb	60	$0.28	$16.80
K_2O		Lb	90	$0.13	$11.70
Custom Application	Tenn Farm Coop.	Acre	1	$4.00	$4.00
Herbicide					
Burndown	Generic Glyphosate	Gal	0.21	$16.00	$3.36
	2,4-D for Resistant Horseweed	Pt	1	$1.81	$1.81
Pre-emergence	Gramoxone Max	Pt	2.2	$4.62	$10.16
	Prowl	Qt	1.5	$5.38	$8.07
Post-emergence	Staple	Oz	1.2	$19.10	$22.92
	Surfactant	Qt	0.08	$3.50	$0.28
Machinery Repair		Acre	1	$3.23	$3.23
Machinery Fuel		Acre	1	$1.05	$1.05
Custom Harvesting[a]		Acre	1	$45.37	$45.37
Operating Capital	Six Months	Acre	205.58	$0.08	$16.45
		Total Variable Expense			$195.40
	Return Above Variable Expense				$200.60
Machinery Fixed Expense					
Production		Acre	1	$7.36	$7.36
Harvesting[b]		Acre	1	$59.57	$59.57
	Total Machinery Fixed Expense				$66.93
	Return to Land, Labor, and Management				$133.67
Labor Expenses					
Production		Hr	0.11	$8.00	$0.90
Harvesting[c]		Hr	0.66	$8.00	$5.28
		Total Labor Expense			$6.18
	Return to Land and Management				$127.49

[a] Custom charge for a corn silage harvester and labor to operate it to harvest kenaf.

[b] Includes fixed expenses for two boll buggies, two module builders, the tractors used to pull them, and a module tarp for each module. Excludes fixed expense for the silage harvester, which is included in the custom harvesting charge.

[c] Includes labor for operating tractors to pull boll buggies and create modules. Excludes labor to operate silage harvester, which is included in the custom harvesting charge.

Table 2. Kenaf Meta-Yield Response Functions, Economically Optimal Nitrogen Rates and Yields, and Plateau Nitrogen Rates and Yields for 30 Soil Types, Base Nitrogen ($0.38/lb) and Kenaf ($55/ton) Prices.

		Nitrogen Rate (lb/acre)		Yield (tons/acre)	
Soil Type	Meta-Response Function	Optimal	Plateau	Optimal	Plateau
ADATON	$2.061+0.072N-0.00015N^2$	210	235	10.4	10.5
ADLER	$1.837+0.070N-0.00015N^2$	205	230	9.7	9.8
ARKABUTLA	$1.235+0.063N-0.00016N^2$	173	196	7.3	7.4
BIBB	$2.358+0.048N-0.00014N^2$	139	166	6.2	6.3
CALLOWAY	$3.821+0.073N-0.00026N^2$	126	140	8.9	9.0
CENTER	$2.846+0.074N-0.00020N^2$	163	181	9.5	9.6
CHENNEBY	$2.684+0.055N-0.00016N^2$	149	173	7.4	7.5
COLLINS	$2.172+0.055N-0.00016N^2$	153	177	7.0	7.1
CONVENT	$0.985+0.065N-0.00013N^2$	222	252	9.0	9.1
DICKSON	$0.995+0.074N-0.00015N^2$	217	241	9.9	10.0
DULAC	$0.697+0.077N-0.00014N^2$	239	265	10.7	10.8
DUBBS	$1.052+0.077N-0.00017N^2$	206	228	9.7	9.8
ENNIS	$1.912+0.053N-0.00014N^2$	166	194	6.9	7.0
ENVILLE	$0.766+0.060N-0.00013N^2$	196	224	7.4	7.5
FALAYA	$5.288+0.053N-0.00025N^2$	89	104	8.0	8.0
FALKNER	$1.097+0.071N-0.00014N^2$	225	252	10.0	10.1
GRENADA	$0.543+0.076N-0.00015N^2$	232	258	10.2	10.3
HENRY	$0.972+0.075N-0.00014N^2$	241	268	10.8	10.9
IUKA	$0.911+0.058N-0.00015N^2$	172	197	6.5	6.6
LEXINGTON	$1.111+0.077N-0.00017N^2$	203	225	9.6	9.7
LORING	$0.880+0.075N-0.00014N^2$	234	261	10.5	10.6
MANTACHIE	$2.223+0.053N-0.00016N^2$	145	169	6.6	6.7
MEMPHIS	$1.337+0.078N-0.00015N^2$	235	260	11.4	11.5
MOUNTVIEW	$1.414+0.071N-0.00017N^2$	193	216	9.0	9.1
OCHLOCKONEE	$2.247+0.062N-0.00014N^2$	193	220	8.9	9.0
PROVIDENCE	$1.109+0.072N-0.00015N^2$	215	241	9.7	9.8
ROUTON	$2.053+0.074N-0.00023N^2$	145	162	7.9	8.0
SMITHDALE	$1.628+0.062N-0.00014N^2$	193	219	8.3	8.4
VICKSBURG	$2.152+0.071N-0.00029N^2$	111	124	6.5	6.6
STEENS	$2.403+0.045N-0.00010N^2$	183	220	7.2	7.4

Table 3. Sensitivity Analysis on the Returns to Land and Management for Kenaf Production for Changes in Yield and Price.

	Percent of Optimal Yield				
Kenaf Price	60%	80%	100%[a]	120%	140%
Average over all soils			$/acre		
$35.00	-$151.93	-$109.17	-$66.41	-$23.66	$19.10
$45.00	-$100.22	-$39.31	$21.60	$82.51	$143.42
$55.00	-$47.58	$31.45	$110.48	$189.51	$268.55
$65.00	$5.52	$102.66	$199.79	$296.93	$394.06
$75.00	$58.90	$174.12	$132.74	$404.57	$519.79
Memphis Soil					
$35.00	-$134.62	-$80.03	-$25.44	$29.14	$83.73
$45.00	-$68.39	$9.29	$86.98	$164.66	$242.34
$55.00	-$1.13	$99.62	$200.37	$301.12	$401.87
$65.00	$66.65	$190.44	$314.24	$438.03	$561.83
$75.00	$134.74	$281.56	$428.38	$575.20	$722.02
Bibb Soil					
$35.00	-$173.25	-$143.71	-$114.16	-$84.62	-$55.07
$45.00	-$138.14	-$95.83	-$53.52	-$11.20	$31.11
$55.00	-$101.96	-$46.91	$8.14	$63.19	$118.24
$65.00	-$65.22	$2.54	$70.30	$138.06	$205.82
$75.00	-$28.17	$52.28	$132.74	$213.19	$293.65

[a] Optimal yield was 8.7 tons/acre averaged over all soils, 11.4 tons/acre for Memphis soil, and 6.2 tons/acre for Bibb soil. Yield sensitivity analysis reflects changes in harvesting costs that might occur on differing productive landscapes. Nitrogen is assumed to be applied at the optimal rate.

Table 4. Comparison of Returns to Land and Management for Kenaf and Competing Crops by Soil Type, Base Nitrogen ($0.38/lb) and Kenaf ($55/ton) Prices.

Soil Type	Crop Land	Corn	Wheat	Soybeans	Cotton	Kenaf	Optimal Crop	Kenaf Acreage
	(acres)	………………..	($/acre)	………………….				(acres)
ADATON	134	94	-15	91	257	256	Cotton	
ADLER	118	88	-18	103	264	220	Cotton	
ARKABUTLA	12,946	41	-35	53	125	99	Cotton	
BIBB	594	22	-55	28	50	54	Kenaf	594
CALLOWAY	8,278	76	-12	61	172	208	Kenaf	8,278
CENTER	7,257	86	-14	71	225	225	Kenaf	7,257
CHENNEBY	39	73	-18	61	203	114	Cotton	
COLLINS	38,588	51	-26	45	138	91	Cotton	
CONVENT	13	67	-25	96	204	174	Cotton	
DICKSON	89	81	-22	99	229	223	Cotton	
DULAC	4,078	95	-21	106	267	261	Cotton	
DUBBS	3,422	87	-21	108	264	220	Cotton	
ENNIS	62	39	-42	48	117	82	Cotton	
ENVILLE	3	31	-48	52	89	93	Kenaf	3
FALAYA	53,147	78	-6	46	164	171	Kenaf	53,147
FALKNER	287	88	-22	96	259	226	Cotton	
GRENADA	49,930	85	-24	100	248	237	Cotton	
HENRY	2,988	74	-23	82	202	267	Kenaf	2,988
IUKA	10,316	21	-58	36	54	58	Kenaf	10,316
LEXINGTON	53,112	88	-20	107	261	216	Cotton	
LORING	53,794	89	-22	107	250	252	Kenaf	53,794
MANTACHIE	318	38	-39	36	100	73	Cotton	
MEMPHIS	47,119	117	-17	122	328	299	Cotton	
MOUNTVIEW	55	80	-20	95	241	186	Cotton	
OCHLOCKONEE	156	81	-21	102	244	182	Cotton	
PROVIDENCE	29,193	76	-24	102	229	213	Cotton	
ROUTON	18,552	58	-24	30	134	147	Kenaf	18,552
SMITHDALE	21,097	73	-21	84	212	146	Cotton	
VICKSBURG	7,263	53	-24	52	132	83	Cotton	
STEENS	878	35	-43	36	109	93	Cotton	
Total	423,825	33,619[a]	-8,848[a]	35,312[a]	92,093[a]	84,328[a]		154,930

[a] Total return to land and management if all land were planted to the crop in the column ($1,000).

Table 5. Potential Kenaf Supply Response to Changes in the Farm-Gate Price.

Farm-Gate Kenaf Price	Optimal Kenaf Production (Nitrogen Price = $0.19/lb)	Optimal Kenaf Production (Nitrogen Price = $0.38/lb)	Optimal Kenaf Production (Nitrogen Price = $0.57/lb)
($/ton)		(1000 tons)	
$35.00	0.0	0.0	0.0
$45.00	0.0	0.0	0.0
$55.00	1,323.8[a]	1,385.7	1,373.4
$65.00	3,937.5	3,921.1	3,893.7
$75.00	3,939.1	3,926.8	3,906.3

[a] At a nitrogen price of $0.19, kenaf is no longer the profit-maximizing crop for the Center soil type. Total kenaf acreage decreases by 7,257 at an optimal yield of 9.51 giving a reduction in production of 69,033 tons. Other than for a kenaf price of $55/ton, kenaf is the profit-maximizing crop on the same soil types for a given kenaf price regardless of the nitrogen price.