8-2006

Tennessee's Kenaf Market Potential as a Feedstock in the Production of Paper

Gerry Solano Avila
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Gerry Solano Avila entitled "Tennessee's Kenaf Market Potential as a Feedstock in the Production of Paper." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Burton C. English, Major Professor

We have read this thesis and recommend its acceptance:

John Brooker, Kimberly Jensen

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

To the Graduate Council:

I am submitting herewith a thesis written by Gerry Solano Avila entitled "Tennessee's Kenaf Market Potential as a Feedstock in the Production of Paper." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

Burton C. English, Major Professor

We have read this thesis
and recommend its acceptance:

Accepted for the Council:

Vice Chancellor and
Dean of Graduate Studies

Tennessee's Kenaf Market Potential as a Feedstock in the Production of Paper

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Gerry Solano Avila
August 2006

Dedication

To my beloved wife, Julie Ann, and two wonderful kids, Kurt Dominic and Julia Feliz;
my mother Felicula Avila; my sisters; and my in-laws
for your love, sacrifices, prayers, support and encouragement
that helped me endure the challenges of graduate student life

and in memory of my father late Gregorio F. Avila

This thesis is humbly dedicated.

Acknowledgements

I would like to express my profound gratitude to the people and the government of the United States of America as well as the government of the Republic of the Philippines through the Department of Agriculture for making it possible for me to pursue graduate studies in the U.S.A. under the Fulbright - Philippine Agriculture Scholarship Program. Sincere appreciation is also extended to the Philippine-American Educational Foundation (PAEF) – administrator of the Fulbright Scholarship Program in the Philippines, the Institute of International Education (IIE) and the Department of Agricultural Economics, The University of Tennessee, Knoxville for the financial assistance awarded to me throughout the duration of my study. The UT Agricultural Economics Department has my "home away from home."

I wish to convey my deepest appreciation to the following people, as this thesis would not have been possible without their help, guidance and straight forward critiquing: Dr. Burton C. English, my major professor, for the invaluable suggestion, professional insights and patience in the course of thesis development. Sir, thank you so much. Two years under your supervision was indeed a great academic learning experience. To my research committee members, Dr. Kimberly Jensen and Dr. John Brooker, thank you so much for the invaluable suggestions and comments that further strengthened my paper.

I also would like to take this opportunity to thank the AgEcon faculty and staff, fellow graduate students and friends for the help, support and camaraderie. Truly, two-year stay in the Department of Agricultural Economics was very memorable and worth noting. Jamey Menard and Mary Gage, many thanks for helping me produce and print the necessary maps in this study. Likewise, thanks to Alejandro, Harwood, Jon, Alex, Bryan, Michael, LaKeya, Vicky, Gena, Katy and Yuling for the help, encouragement, and great luncheon conversations you have shared. Funny, but mind you, I will always remember you all every time I take my lunch.

Recognition is also extended to the Department of Agriculture, Regional Office 7 (DA-RFU7), Cebu City, Philippines, for the allowing me to go on a two-year study leave to pursue graduate studies in the United States. To the staff of the Agribusiness and Marketing Assistance Division of DA-RFU7, Cebu City, for the untiring support and encouragement, thank you all so much.

My sincere thanks and appreciation to my beloved family: Wife, kids, mother, sisters and in-laws who have always been there to support and sacrifice for me through thick and thin. You are all the sources of my strength, inspiration and determination to go through the most difficult task embedded in the graduate student life. Two years of being away from home has never been easy.

Above all, thank you dear God for the life, good health, wisdom, guidance and the many blessings you have bestowed on me and to my family. This rare and wonderful opportunity was made possible because of you LORD. I never dreamed of having the opportunity to one day able to complete my graduate studies in the United States of America!

Abstract

The goal of this study was to assess the production feasibility and market potential of using kenaf as a feedstock for paper production in Tennessee. This thesis 1) evaluates the potential for growing this crop in Tennessee by comparing the cost and return and the break-even price for kenaf with soybean, corn, cotton and wheat, 2) identifies potential suitable production areas in the state of Tennessee, 3) analyzes the marketing opportunities that could be developed for kenaf at a price that growers would be willing to produce it, 4) identifies potential kenaf marketing structure and marketing channels, and 5) identifies potential marketing problems of kenaf.

The economic feasibility of kenaf in Tennessee was evaluated using simulation, budgeting and sensitivity analysis. EPIC simulations were conducted for kenaf along with the dominant crops for 202 Tennessee soil types and 18 nitrogen levels. Quadratic plus plateau response functions were estimated. Profit-maximizing nitrogen fertilization rates and yields were identified for each soil using these quadratic response functions. Finally, the marketing of kenaf was assessed using the Strategic Marketing Management to analyze marketing potential of kenaf.

Results showed that kenaf is economically feasible to produce in some regions in Tennessee at a nitrogen price of $0.38/lb and a kenaf price of $55 per ton. The net returns to land and management vary across regions. The average lowest net return to land and management obtained was $60.22 per acre while the highest was $150.04 per acre. Average breakeven prices[1] ranged from $19.75 to $74.69 per ton.

---

[1] Prices above the breakeven in each region give a positive net return to land and management to producers.

Analysis revealed that kenaf was not sensitive to changes in nitrogen prices across regions. Increasing (decreasing) the nitrogen price to 5%, 15% and 25%, profitability decreased (increased) by only 3%, 7% and 13%. Nevertheless, kenaf was sensitive to changes in output prices. Varying the price below and above 5%, 15% and 25%, profitability decreased (increased) by 21%, 54% and 90%.

Market structure of kenaf resembles that of small monopoly and monopsony at the production side because there is no open market. The "chicken or egg" dilemma was a major problem to commercialization. Without established market, kenaf is riskier to produce than dominant crops. However, cooperative contract growing reduces marketing risks. This study will aid producers, cooperatives, prospective investors and policy development planners in making investment decisions in the future.

Table of Contents

List of Tables

TABLE PAGE

Part II: Economic Viability of Producing Kenaf in Tennessee

List of Tables

TABLE PAGE

List of Figures

FIGURE PAGE

Part II: Economic Viability of Producing Kenaf in Tennessee

Part III: Marketing of Kenaf in the State of Tennessee

Part I: Introduction

The pulp and paper industry continue to face enormous challenges to address the growing demand of better quality paper products. In the United States, 90% of the writing paper is made from virgin tree fiber. American magazines and newspapers alone account for the loss of 272 million trees annually which is roughly equivalent to one tree per person annually (SERC, 2003). Finding viable, low input alternative pulp sources offers huge potential to the industry. Since the 1940's, the United States Department of Agriculture (USDA) began to search for new fiber crops that can be used as raw material for commercial papermaking. Of the 500 different non-food crops evaluated, kenaf offers the most viable substitute for trees for commercial pulp and papermaking because of its excellent fibers and economic feasibility.

Kenaf (*Hibiscus cannabinus* L. Malvaceae) is a warm season, fast growing annual non-wood crop that can be cultivated and harvested for fibers to make specialty papers and good quality newsprints, cordage, animal feeds and bedding, insulator and industrial absorbents. A family of Okra and cotton, this new crop can be planted in a relatively wide range of climate and soils (Taylor, 1995). It can also be planted on poor soils with minimal fertilization and water compared to other conventional agronomic crops. However, it grows best under well-drained, sandy and loam soil (Johnson, 2001). It also flourishes in regions with high humidity, loamy soils with abundant rainfall and a long growing season (Burgess, 2004). Optimum growth can be obtained in areas with warm temperature and sufficient water in the first five months of planting to stimulate vigorous growth. Kenaf grows fast reaching to a height of 12 to 18 feet high in four to five months and can be grown in regions where cotton and tobacco thrive (Valigra, 2000). Baldwin (2000) indicated that kenaf can be grown in rotation with corn - cotton and still yield feasible results. In Indonesia, farmers would increase profits by following on rotation of corn followed by kenaf as prevailing corn yields and prices provided more remuneration to farmers (Liu, 2002). The advancement of conservation tillage coupled with the crop's inherent ability to suppress annual weed cycles and require minimal management and input, make it clearly a crop to consider (Nelson, 1999). Large quantities of herbicides are not required because close planting density suppresses weeds growth. In addition, pesticides are not necessary because fibrous stems depress insects from attacking the crop. Kenaf is tough, fibrous plant that resembles a very tall okra plant with similar leaves and blossoms (Kenaf Industries of South Texas, 2003). It has been developed as a non-wood fiber crop as an attractive feedstock for pulp and papermaking. Essentially, the JCN Network (2003) published that kenaf grows quickly and has the highest CO_2 absorption capacity of any plant, thereby helping to prevent global warming. Its fiber is commonly used as substitute for existing materials for paper. It requires less energy to pulp than trees and no bleaching is required because the fibers are naturally white.

One of the most important deciding factors for kenaf commercialization is market development and available kenaf processing plant. Successful commercialization depends on the local cost comparisons which consider economies of scale, transportation and local processor demand (LeMahieu et al., 1991).

Kenaf is relatively potential crop to emerge in Tennessee marketplace. Interest in the production of kenaf has risen recently because of several influential factors such as interests in the South as a production area by foreign investors, concerns over decreasing pulp supplies, as well as government and consumer demand on the tobacco industry (Nelson and Cook, 1998). Furthermore, the USDA-ARS (2000) found that U.S. farmers could plant kenaf in place of corn, soybeans, cotton, or rice. However, ARS added that such change depends on the magnitude of economic return that farmers get out of their investment.

Kenaf must be grown in a cropping system where it can produce sufficient yields to compete economically with other crops (Taylor, 1984). Small and medium-sized pulp mills can be situated near the kenaf farms to take ready advantage of the fiber (Rethink paper, 2006). Hence, entrepreneurs need to persuade customers to purchase the product. However, customers who are willing to buy require large volumes and ultimately, need to convince farmers to expand production.

Initially, this paper assumed that kenaf could be economically grown and marketed in the state of Tennessee, thus, this crop has the potential to draw acreage away from traditional crops. Taylor (1984) concluded that kenaf is expected to compete with traditional crops provided that price of kenaf is same as that of pulpwood. Nevertheless, he added that this profitability is dependent on location-specific factors.

The overall goal of this study was to assess on the market potential of producing kenaf as raw materials for paper production. Specifically, this thesis would: 1) evaluate the potential for growing this crop in Tennessee by comparing the cost and return and the break-even price for kenaf with soybean, corn, cotton and wheat, 2) identify potential suitable production areas in the state of Tennessee, 3) evaluate marketing opportunities that could be developed for kenaf at a price that growers would be willing to produce it, 4) identify potential kenaf marketing structure and marketing channels in the state of Tennessee, and 5) identify potential marketing problems of kenaf.

References

Baldwin, B.S. "Growing Kenaf on a Commercial Scale in Mississippi". Dept. of Plant and Soil Sciences, Mississippi State University. 2000. Web accessed on March 15, 2005 at http://www.kenafsociety.org/Abs2000.htm.

Burgess, C. "Kenaf". *Carolina Country*. July 2004, pp 22-23. Web accessed on March 23, 2005 at http://www.carolinacountry.com/storypages/ourstories/kenaf/ kenaf.7.04.pdf

JCN Network. "NEC Announces Development of High-Strength Highly Heat Resistant Bioplastic; Featuring Polylactic Acid Reinforced with Kenaf Fiber." 2003. Available at http://www.japancorp.net/Article.Asp?Art_ID=4708. Web accessed on January 24, 2005

Johnson, J. "Alternative Agriculture: What is Kenaf?" Rural Enterprise and Alternative Agricultural Development Initiate Report (Report 1). 2001. Web accessed on March 23, 2005 at http://www.sin.edu/~readi/grains/factsheets/ kenaf.pdf.

Kenaf Industries of South Texas L.P. "Kenaf: An Annual Crop Source for Fiber." 2003. Web accessed on January 24, 2005 at http://www.kenaf-industries.com.

LeMahieu, P.J., E.S. Oplinger and D.H. Putnam. "Kenaf". Alternative Field Crops Manual. Department of Agronomy, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin – Madison. 1991. Web accessed on August 2, 2005 at http://corn.agronomy.wisc.edu/alternativeCrops/ kenaf.htm.

Liu, A. "Making Pulp and Paper from Kenaf." 2002. Web accessed on March 23, 2005 at http://www.Chinaconsultinginc.com/paperpulp.html.

Nelson, P. "Kenaf and Conservation Tillage: A Natural Economic and Environmental Match Vancil Brothers Farm Grows No-Till kenaf in Southeast Missouri." Agro-Tech Communications. AgFiber Technology News, January 19, 1999, Vol.1, No. 2. Web accessed on August 2, 2005 at http://lists.essential.org/ag-res/msg00010.html

Nelson, P.A. and Cook, A.L. "Cultivating Kenaf for Fiber in Tennessee." 1998 (Abstr). Web accessed on August 2, 2005 at http://www.aaic.org/98progrm3.htm

Taylor, C.S. "A Systems Approach to Commercialization of Kenaf". Ph.D. Dissertation, University of Missouri-Columbia, May 1984.

Taylor, C.S. New Crop Factsheet. 1995. Website accessed on March 24, 2005 at http://www.hort.purdue.edu/newcrop/cropfactssheets/kenaf.html.

ReThink Paper. "Kenaf – The Clean Paper Crop." 2006. Web accessed on April 10, 2006 at www.rethinkpaper.org/content/kenaf.cfm

State Environmental Resource Center (SERC). "Alternative Fiber Products." Madison, Wisconsin. 2003. Web accessed on Mach 24, 2005 at www.serconline.org/fibers.html.

U.S. Department of Agriculture – Agricultural Research Service. 2000. "New Uses of Kenaf." Web accessed on June 15, 2006 at www.ars.usda.gov/is/AR/archive/aug00/kenaf0800.htm.

Valigra, L. "Tough as Soybeans: The Long Search for Plants with Optimal Material Properties Starts to Pay off." Global Hemp. 2000. Web accessed on January 24, 2005 at http://www.global hemp.com/Archives/Magazines/tough-as_soyben.html.

Part II: Economic Viability of Producing Kenaf in Tennessee

Introduction

Since the 1940's, the USDA began to search for new fiber crops that can be used as raw materials for commercial papermaking. Of the 500 different non-food crops evaluated, kenaf shows the most viable substitute for commercial pulp and papermaking because of its excellent fibers and economic feasibility.

Currently, most of the paper made in the United States comes from pulp made from wood fibers (AF&PA, 2002). The pulp industry owns a portion of its supplies and marketing contracts with wood lot producers for the remainder of its needs. This is known as tapered integration of the industries feedstock. Contract growing and tapered integration are the typical marketing practices among wood producers and pulpwood manufacturers to maintain price and supply inventories of raw materials. No firm is self-sufficient in pulpwood supply; indeed, on the average, firms with a forestland base were able to supply only 20% of their wood fiber needs (Stier et al., 1986).

Kenaf (*Hibiscus cannabinus* L.) is a warm season, fast growing annual non-wood crop that can be cultivated and harvested for fibers to make specialty papers and good quality newsprints, cordage, animal feeds and bedding, insulator and industrial absorbents. This new crop can be planted in a relatively wide range of climate and soils (Taylor, 1995). It needs minimal fertilization and water compared to other conventional agronomic crops. It grows best under well-drained, sandy and loam soil (Johnson, 2001). It also flourishes in regions with high humidity, loamy soils with abundant rainfall and long growing season (Burgess, 2004). Valigra (2000) cited that it grows fast reaching to a height of 12 to 18 feet high in four to five months and can be grown in regions where cotton and tobacco thrive. Furthermore, kenaf can be grown in rotation with corn -

cotton and still yield feasible results (Baldwin, 2000). In Indonesia, farmers would increase profits by following on rotation of corn followed by kenaf at prevailing corn yields and prices provided more remuneration to farmers (Liu, 2002). The advancement of conservation tillage coupled with the crop's inherent ability to suppress annual weed cycles and require minimal management and input, make it clearly a crop to consider (Nelson, 1998). Large quantities of herbicides are not required because close planting density suppresses weeds growth. In addition, pesticides are not necessary because fibrous stems depress insects from attacking the crop. Kenaf has been developed as a non-wood fiber crop as an attractive feedstock for pulp and papermaking. Essentially, the JCN Network (2003) published that kenaf grows quickly and has the highest CO_2 absorption capacity of any plant, thereby helping to prevent global warming. It has been commonly used as a substitute for existing materials such as paper fiber. Minimal energy is required to pulp and requires no bleaching because the fibers are whiter than trees.

The first three objectives in the study are accomplished using the data generated from various EPIC runs. An average kenaf yield for each Tennessee region was calculated. Quadratic-plus-response plateau functions (QRP) were estimated for kenaf and traditional crops such as corn, cotton, soybeans and wheat for typically in Tennessee soils. Both break-even and sensitivity analyses were employed to determine the price level where kenaf production is economically feasible. Results of this study greatly aid cooperatives, producers, prospective investors and policy development planners in investment decision making purposes.

Related Literature

Kenaf is a non-wood crop belonging to hibiscus family that has been used for thousands of years in Africa and parts of Asia as a source of fiber and animal food. Because of African origin, it cannot run wild across the country because its seeds require an additional 60-90 days of frost free conditions to mature (Johnson, 2001). China is known for using non-wood plant fibers as feedstock for pulp and papermaking many years ago. In 2003, China is the largest kenaf producer in the world with 150,000 acres under cultivation (Motavalli, 2004). In 1996, United States has approximately 4,300 acres under cultivation: 2,000 acres grown in Mississippi, 1,200 acres in Texas, 560 acres in California with little acreages in Louisiana, New Mexico and Georgia (Llyod and Seber, 1996). However, in 2003, kenaf production acreages increased to approximately 10,000 to 15,000 acres (Motavalli, 2004) of which 4,500 acres were grown in North Carolina (Burgess, 2004).

Harvesting for kenaf continues to be an important aspect of commercialization (Webber et al., 2002). Harvesting date varies depending on the location of the state where crop is grown and the time required for kenaf for drying unless artificial heat is used (Cross, 2005). Ideally, it is harvested in late fall or winter every year. Wood and de Jong (2000) illustrated that vegetative growth stops soon after the beginning of flowering and this is the optimum time for harvesting whether the crop is being grown for textile fiber or for paper pulp. It should be harvested with a forage chopper or silage to meet the processing needs of paper manufacturing. It may be profitable to utilize existing commercial harvesting and processing equipment rather than investing in the development of kenaf specific equipment.

Kenaf is topped at 12 feet and laid down to dry in the field for ten days, cut into one-ft billets, and blown into an accompanying dump buggy (Taylor, 1995). After the fiber is harvested, it is pressed into large modules and stored outdoors near the farm. A good plastic cover will protect the fiber and it can be stored up to four years still producing excellent fiber quality (Johnson, 2001 and Rymsza, 1999). Kenaf can also be stored as pellets for use either as fiber or forage crop. "Pelletizing" increased its density by at least 390 percent, thus, reducing both transportation and storage costs (Cross, 2005). The low bulk density of kenaf stalk affects management decisions concerning the economic transportation and storage of the kenaf material (Webber et al., 2002). When harvested, kenaf is not a dense crop and therefore it is bulky and expensive to transport. Hill (1986) illustrated that an eighteen-wheeled truck is able to hold only 9000 pounds.

Yields of kenaf in research plots varied widely from 2.5 tons/acre at Rosemount, Minnesota to 15 tons/acre at College Station, Texas (LeMahieu, 1991). Kenaf could potentially yield from six to ten tons/acre of dry fibers (Johnson, 2001). In West Tennessee, Roberts et al. (2005) indicated that kenaf base yield is 7.20 tons/acre. Nevertheless, new varieties yield as much as 12 tons per acre (Liu, 2002). Late maturing varieties have higher yields than the early maturing ones (FAO, 2003). This accounts that in one growth season yield is three to five times greater than the annual growth of southern pine trees which take seven to forty years to reach harvestable sizes (Johnson, 2001).

The federal government does not gather statistics on production or use of kenaf. The lack of an established market for kenaf makes it impossible to collect historical price data for kenaf (Kalo et al., 1999). Nevertheless, some studies showed that total production cost of kenaf is $237 per acre (Rymsza, 1999). Prices for pulpwood vary by region and other market factors, and are typically sold between $39.54/ton (Rymsza, 1999) to $55/ton (Hill, 1997). As in any other food crops, prices received by producers are identified based on contract negotiation between producers and processors (LeMahieu et al., 1991). With a six-ton per acre yield, kenaf priced at $55 per ton provides a net return to the farmer of $144 per acre (Rymsza, 2000). Recently, Roberts et al. (2005) developed a kenaf budget for West Tennessee indicated that yields and prices were the most uncertain items in the cost and return budgets. Based on calculations, kenaf total cost of production is $286.90/acre. Of which, the total variable cost is $213.80/ac while machine and labor cost constitute $93.11/ac. At base price of $55/ton, the net return to land, management, and risk was $32.85/acre.

In the report edited by McNulty (2005), The Report to the Governor's Hemp and Related Fiber Crops Task Force, indicated that crop prices above $60 per ton would probably be required to interest most producers. In order to receive profits from kenaf, growers must be located within 30 to 40 miles of a processing facility because the harvested stalks are too bulky to ship any distance (Burgess 2004). Similarly, Kalo et al., (1998) described that kenaf was feasible if one of the following conditions prevailed: a) Kenaf price of $120 per ton; b) a kenaf of yield eight metric ton per acre, or c) a kenaf processing plant located within 50 miles. Moreover, they added that if compared to the net returns of a mixed wheat-soybean and vegetable system, kenaf would be feasible if its price is \$100 per ton, or yield is 7 MT/acre or the raw product could be delivered to a processing plant less than 50 miles away. However, this largely depends on the location of processing facilities and appropriate market for farmers. It is important to stress that the price of the current kenaf is merely a result of the very infant status of the kenaf industry, and the relatively small scale processing (Rymsza, 1998).

Research and development efforts are gearing toward several other potential industrial uses for the kenaf fibers. Kenaf can be made to high-end agro-industrial products like paper, textiles, absorbents, auto insulator, animal bedding, seeded mats, modeled plastics, erosion mats, fiber glass substitute and wall paper as well as livestock feeds. Nonetheless, among the many applications of kenaf fibers, pulp and papermaking have drawn considerable attention and became the focus of paper industries for years (Liu, 2002). Kenaf works well either alone or blended with recycled paper or virgin pulp because it is stronger, whiter, longer lasting, more resistant to yellowing, and has better ink adherence than tree paper due to kenaf fibers peculiar properties (Taylor, 1995). Newspapers made from kenaf pulp have brighter and better looking, reduced runoff, richer color photo reproduction and good print contrast (LeMahieu et al., 1991). Kenaf paper is quite stiff and bulky and performs well in high-speed sheet-feeding copy and press machines (The Vaults of Erowid, 2003). Quality analysis also showed that kenaf newsprint have superior tear, tensile and burst ratings.

Waste in kenaf production is double that of normal trees, however, the total cost of the waste is minimal because kenaf can produce 300 to 500% more pulp per acre, per year than trees at half the cost (Ogden, 2005).

In the United States, experiments in producing kenaf as feedstock for pulp revealed that the unit costs would be about half that of producing pulpwood and would produce three to five times as much as dry materials for pulping per unit land annually (Liu, 2002). Johnson (2001) noted that it takes 15 to 25 percent less energy to pulp than wood pulp because it contains less lignin. Bleaching ingredients consist mainly of hydrogen peroxide which makes the treatment process more environment-friendly. All water used during the pulp treatments can be readily used for irrigation purposes (Ogden, 2005).

As demand for kenaf paper increases, it will provide a low input, rotational crop for farmers that have a real market potential (Davis, 2003). Scott and Taylor (1990) described that once the market has been developed, projected returns of kenaf compare favorably with that of white corn, grain sorghum and upland cotton. This implies that farmers' keep more dollars per acre by growing kenaf than they generally can expect to receive from corn or cotton because kenaf crop requires fewer inputs and less vulnerable to agro-climatic and pest factors.

Kenaf is a seasonal crop harvested once a year, which has become the biggest constraint for continuously providing raw materials to paper mills for kenaf papermaking. Pulp and paper are in operation all year round. Liu (2002) noted that supply of kenaf has been erratic and limiting for pulp and paper production. He added that as a result, it will be important for kenaf to be stored in large quantities in order to have enough fibers to meet mill needs between harvests. For large scale production, a number of large areas in close proximity to the plant are needed to guarantee sufficient and continuous supply of raw materials.

This annual crop could facilitate the expansion of existing mills or construction of new facilities. To date, current market is nearly non-existent with some paper production occurring in traditional pulp and paper mills. Many pulp facilities that currently process yellow pine could be converted to accommodate kenaf. Undeniably, some modification and expenses are often necessary in order to process modules of kenaf fiber instead of pulpwood. However, the modification of facilities and machineries can be recovered in a shorter period because of the reduction in freight and energy costs (Liu, 2002).

Basically, people are reluctant to get involved because of the financial risk where market still has to be developed Hill (1997). Demonstrating the profitability of the crop is a significant step to developing the required acreage that will allow investors to construct processing plants. Despite kenaf's apparent promise as a ready source of fiber, the lack of any nearby market makes this crop unsuitable at this time (New Crop Opportunities Center, 2002). It is difficult to convince farmers to switch kenaf cultivation because higher returns can be obtained through cultivation of conventional crops like corn, wheat or soybean. Recognizing this problem, a viable market for selling kenaf fiber is vital for farmers to switch from a traditional crop.

Numerous production studies have examined the economic feasibility of a new crop. Different models and methodologies were used to examine new crops economic feasibility. Proper model selection is one of the most important steps in any modeling exercise because it will provide agricultural managers with a powerful tool to assess simultaneously the effect of farm practices on crop production as well as on soil and water resources (Priya and Shibasaki, 1998).

Hewlett et al. (1996) investigated the economic feasibility of planting improved variety of Alfalfa in Wyoming using the partial budgeting technique. This technique involves four categories of costs and returns: 1) reduced costs, 2) increased returns, 3) increased returns, and 4) reduced returns. However, to evaluate further the economic feasibility of improved variety of alfalfa, the Net Present Value (NPV) and Modified Internal Rate of Return (MIRR) were calculated for both the Ranger and improved alfalfa varieties. MIRR is a like a "breakeven" rate of return for investment. Timing of cash flow, opportunity interest, and other factors necessary to compare investment alternatives were considered in the analysis. Incremental yield increases at different interest rates were assumed. The findings of the study suggested that NPV declines when higher opportunity cost is assumed for the time value of money. In addition, NPV declines from \$35.61/ac (for i = 0 percent) to \$19.23/ac (for i = 13 percent) when the improved variety yields 5 percent more than Ranger. Nevertheless, NPV increases as yield increases.

A recent study of Wright et al. (2000) examined the economic feasibility of switchgrass and other crops suitable for bioenergy production in the United States utilizing the modified Agricultural Sector Model (POLYSYS). POLYSYS is an agricultural policy simulation model of the U.S. agricultural sector that includes simultaneous block and linear programming modules. The study assumed two different price scenarios to assess the potential supply of switchgrass at \$33/ton and \$44/ton for scenario 1 and scenario 2, respectively. Normal production practices were all assumed for all crops. Results showed that at a higher farm gate price, 17 million hectares of cropland in the United States could produce energy crops at a profit greater than the existing agricultural uses but at a lower farm gate price, only about 7 million hectares would be profitable for energy crop production.

The economic feasibility of adopting kenaf on the Eastern shore of Virginia was examined using the linear programming model (Kalo et al., 1999). The model evaluated the economic performance of two representative farms with distinct cropping system along with kenaf, typical for the region. Rotational constraints were established in order to prevent planting the same crop in a field in two consecutive years. Because of lack of an established market for kenaf, prices specified in the analysis were based in the mid-Atlantic region proposed contract. Results indicated that kenaf could not provide the same returns to investment given the limited resources of each farm. Kenaf was profitable only if price exceeded $75/ton or yield was more than 12 ton/ha.

Roberts et al. (2005) evaluated the economic feasibility of kenaf in three counties in West Tennessee using budgeting, simulation and breakeven analysis. Initially, several literatures on kenaf production were reviewed to develop a base budget. This budget was modified to determine the economically optimal nitrogen rates and yields of kenaf in different soils. Environmental Productivity Impact Calculator (EPIC) was used to simulate crop growth over a 100-yr period. EPIC simulation model was selected because it has the capability to simulate multiple crops. Profit-maximizing nitrogen fertilizer and yields from kenaf meta-yield response from EPIC per soil were determined. The generated meta-response functions were estimated using the quadratic-plus-plateau functions (QRP). QRP is appropriate to estimate yield response to nitrogen application because this considers random variation in other limiting factors across space and time especially weather (Kastens et al., 2005). In addition, they described that QRP is appropriate to estimate Nitrogen (N) fertilizer response because price of N significantly affect optimal response. They added that an incremental change in fertilizer on crop price will induce an incremental change in the economic optimum fertilizer rate. Finally, breakeven prices in each region were calculated. The findings of the study indicated that economically optimal nitrogen rates vary from 89 lb/ac in Falaya soil to 241 lb/ac in Henry soil, while yield of kenaf per acre was as low as 6.3 tons/ac in Bibb soil to as high as 11.5 tons/ac in Memphis soil. Moreover, comparing kenaf to traditional crops, they found that kenaf consistently competed with cotton as profit maximizing crop in West Tennessee. Nonetheless, at a price below $49/ton, kenaf was not profitable in all soil types. Increasing the price above $67/ton indicated that kenaf is profitable in all soils investigated.

Methodology

This study is similar to that of Roberts et al. (2005) examining the economic feasibility of kenaf production in three counties in West Tennessee except that the coverage was expanded to the whole state of Tennessee. Initially, the entire state was divided into 14 regions (Figure A.1). Various regions in the State were group based on locations viz., West, Middle and East Tennessee. West Tennessee comprised regions 1, 2, 3, 4, 5 and 6; Middle Tennessee includes regions 7, 8, 9, 10 and East Tennessee includes regions 11, 12, 13 and 4. Regionalization of the state was based on the different weather stations located across the state. Counties adjacent to a particular weather station were clustered to constitute the specific region (Table A.1). The dominant crop grown in a particular region was identified based on acreage planted (Figure A.2) using the NASS, USDA data. Competitiveness position of kenaf was compared with the dominant crop grown in a particular region.

Foremost, 202 major[2] soil types were identified that have the potential of being cropped based on the National Resource Conservation Service's STATSGO database. Identified soils within each Mapping Unit ID (MUID) were matched with the potential yield file. The soil is assumed to have the potential to be cropped if a row-crop yield was specified in the database. Each soil area was matched to the amount of land cropped in the 2002 Agricultural Census. These areas were adjusted at the county level so that the area of cropped land based on county and soil type summed to the acres cropped in 2002 within each of the different counties in particular region. Kenaf on these soils has the potential to compete with the dominant crop grown in the region.

Profit-maximizing nitrogen fertilization rates and yields were identified in each soil type from kenaf meta-yield response functions using the Environmental Productivity Impact Calculator (EPIC) to develop data essential to estimating meta-response functions. EPIC is a daily time step model that simulates the physical processes involved in hydrology, nutrient cycling, and plant growth simultaneously and realistically using readily available inputs. Crop growth models can be used to evaluate relationships among crop productivity and selected environmental factors (Roberts et al., 2005). Priya and Shibasaki (1998) illustrated various crop growth simulation models 1) CREAMS and GLEAMS, 2) AGNPS, 3) ANSWERS, 4) SWRRB, 5) DSST and 6) spatial-EPIC. Other examples of crop growth simulation models as cited by Roberts et al., (2005) are CERES and SOYGRO. However, many of these models were designed to simulate crop growth

[2] Soils included in the EPIC crop growth simulation in a particular region should have at least 100 acres

in specific locations such as basin and watershed scales, single rainfall event and single crop growth. Evaluating the economic feasibility of kenaf in Tennessee requires multiple crops simulation. EPIC can simulate more than 80 crops and has been used to evaluate crops required in the analysis such as corn, cotton, wheat, soybeans and kenaf. Because simulation of multiple crops is required in this study, EPIC was selected as a crop growth simulator.

Quadratic response plateau (QRP) functions were employed to estimate the meta-response functions generated through the simulation. Kenaf yields were obtained by increasing the nitrogen rate from 0 to 340 lb/ac using a 20-lb per acre increments. Obtained yield through EPIC simulation for a given nitrogen rate and soil was the average of 100-yr simulated yields. Weather variables were drawn at random across the 14 weather stations within the state of Tennessee. Assumptions included in the analysis were 1) no-tillage production practice, 2) all inputs are specified in the initial budget except nitrogen and, 3) other inputs in the budget were applied at rates sufficient to eliminate yield reductions from insufficient applications. Profit-maximizing nitrogen rates and yields in each soil type were calculated by setting the first derivative of the respective yield response function equal to the nitrogen-to-kenaf price ratio and solving for the economically optimal nitrogen rate. Economically optimal yield in each soil type was calculated using the optimal nitrogen rate substituted into the yield response function.

The initial kenaf budget for each of the 202 major soils was modified by replacing the initial nitrogen rate and yield with the profit-maximizing rates and yields across soil types assuming that other input costs are held constant. The modified budget is designed to estimate the returns to land and management in every soil.

EPIC simulations similar to the ones for kenaf were used to estimate quadratic – plus-plateau corn, cotton, soybeans and wheat meta-yield response functions for nitrogen in each soil type. No-tillage production practices and inputs other than nitrogen were specified in the existing University of Tennessee crop budgets developed by Gerloff (2004). The existing crops' budgets were modified by replacing with 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 were computed using the modified budget.

Kenaf net return to land and management was calculated and compared to net returns of corn, cotton, wheat, and soybeans to identify crop that has the highest return on per soil basis. Considering that nitrogen is not a major input in soybeans production, the budget developed by the University Extension (Gerloff, 2004) was used with yields adjusted by the 100-year average estimated by EPIC.

A kenaf supply curve was estimated by accumulating kenaf production potential at for each price between \$40/ton and \$75/ton. These estimates were made at \$5/ton intervals. For each price, optimal kenaf production in a particular type of soil was calculated as the product of its optimal yield and acreage. The quantity of kenaf supplied for a particular price was the optimal amount of kenaf production summed across soil types for which kenaf was identified as the most profitable crop. The supply curve depicts whether the forthcoming supply of kenaf was sufficient at a price low enough for feasible production.

Two-way sensitivity analysis was applied to analyze changes on kenaf acreages, production level as well as profits by varying base nitrogen price and kenaf output prices. Sensitivity analysis measures the impact on outputs in changing one or two key input variables. This method identified the optimum price level and the corresponding level of kenaf production that are economically feasible and price acceptable for producers to grow.

In a typical farm field, multiple soil types exist. A hypothetical field situation consisting of two soil types was illustrated to provide insights on how investment decision making be made in the actual field. For uniformity, soils were matched to the Tennessee Map Unit ID (MUID) database. Meta-response functions in each soil were weighted at varying soil type proportions from 0% to 100% and solve for optimal nitrogen rates and yield. Finally, net return to land and management for kenaf and the dominant in soils identified were compared and plotted at varying percentages.

Results and Discussion

Despite the diverse utilization of kenaf crop, its market development remains undeveloped. Demonstrating the economic feasibility of kenaf in Tennessee is a vital measure towards commercialization of the new crop.

Comparison of economically optimal nitrogen rates and yield along with the net returns to land and management in Tennessee with a base nitrogen price of $0.38 per pound and price at $55 per ton of kenaf is shown in Table 1. Based on the results, the optimal nitrogen rates in Tennessee ranged from 136.4 to 454.9 pounds per acre. On average, region 13 and 14 have the lowest average optimal nitrogen rates of 204.8 pounds

Table 1. Comparison of economically nitrogen rates and yields and returns in to land and management in Tennessee for kenaf production, base nitrogen price at $0.38 per pound and kenaf price at $55 per ton, 2005

Region*	Total Land cultivated***	Optimal Nitrogen Rate			Optimal Yield of Kenaf			Return to Land, Labor and Management		
		Low***	Average	High	Low	Average	High	Low	Average	High
		--------	(lb/acre)	--------	--------	(ton/acre)	--------	--------	($/Acre)	--------
1	691,144	194.5	294.5	377.8	5.8	8.8	11.1	21.30	122.62	193.97
2	660,457	194.3	285.3	417.2	5.5	8.7	11.8	12.53	117.96	211.43
3	834,668	189.2	261.4	325.9	6.0	7.6	9.1	26.17	77.39	128.82
4	435,469	248.9	324.1	454.9	8.0	9.7	12.5	56.15	150.04	229.37
5	326,912	174.2	264.7	352.8	5.5	8.2	9.9	19.05	103.86	160.76
6	274,039	156.9	235.6	316.6	4.8	7.2	8.5	-6.35	69.28	120.41
7	743,878	172.9	262.3	384.6	5.6	8.5	10.5	22.76	116.87	169.80
8	838,608	201	280.6	389	5.9	8.8	10.9	17.19	123.51	188.97
9	542,296	143.7	221.9	335.4	4.5	6.9	8.7	-23.67	60.22	120.77
10	263,200	156.0	226.7	302.3	5.0	7.4	9.3	-4.39	83.24	149.56
11	175,623	166.6	242.0	324.4	5.4	7.5	9.0	6.51	82.26	145.64
12	248,756	175.7	243.4	325.1	5.4	7.7	9.8	11.10	92.03	166.91
13	528,045	136.4	204.8	275.4	5.7	8.1	9.5	32.32	119.42	176.87
14	429,897	139.6	204.8	296.8	5.0	7.5	9.2	2.61	94.32	158.78

* Regional division of Tennessee as shown in Figure 1

** *Source: USDA, NASS Data

*** Low, average, high are define as

per acre while region 4 has the highest average optimal nitrogen rates required of 325.1 pounds per acre[3].

Optimal yield of kenaf varies from 4.5 tons per acre in region 9 and 12.5 tons per acre in region 4. Region 9 has the lowest average yield of 6.6 tons per acre while region 4 has the highest average yield of 10.3 tons per acre. These differences in optimal nitrogen rates and yield are greatly influenced by weather conditions and soil types.

On the other hand, across regions net return to land and management ranged from as low as -\$23.67 per acre in region 9 and as high as \$229.37 per acre in region 4. On average, net return to land and management showed that region 9 obtained the lowest return of \$60.22 per acre while region 4 had the highest return of \$150.04 per acre.

Table 2 presents net returns to land and management of kenaf and the dominant crops across regions in Tennessee, base nitrogen price of \$0.38 per pound and kenaf price at \$55 per ton. Lowest net return to land and management among the dominant crop was -\$208.23 per acre in region 2 and the highest net return was \$230.94 per acre in region 9. Dominant crops average net return, region 11 obtained the lowest of -\$15.02 per acre while the highest was region 9 with an average return of \$156.62 per acre.

On the other hand, kenaf lowest net return to land and management was -\$23.67 per acre obtained in region 9 while the highest was \$229.37 per acre in region 4. On average, kenaf lowest net return was \$60.22 per acre in region 9 and the highest was \$150.04 per acre in region 4. As a profit maximizing crop, at a price of \$55 per acre,

[3] N rates are higher than those in previously published works. This may be a result of the simulation model overestimating the yield response to N at the higher undocumented levels. However, the same model was also used to estimate traditional crop yields and N requirements.

Table 2. Comparison of Returns to land and management of kenaf and dominant crop across 14 Regions in Tennessee, base nitrogen price at $0.38/lb and a kenaf price at $55 per ton, 2005

Region	Dominant Crop* in the Region	Ranges of Returns to Land, Labor and Management for:						Kenaf Returns	
		Dominant crop			Kenaf			Soil Type**	
		Low	Average	High	Low	Average	High	Low	High
		($/Acre)							
1	Soybeans	30.42	111.06	164.53	21.30	122.62	193.97	Bruno	Memphis
2	Cotton	-208.23	16.56	212.06	12.53	117.96	211.43	Bruno	Memphis
3	Soybeans	54.79	110.11	158.93	26.17	77.39	128.82	Bibb	Taft
4	Soybeans	42.15	117.48	175.56	56.15	150.04	229.37	Saffell	Memphis
5	Soybeans	20.22	108.46	162.21	19.05	103.86	160.76	Bruno	Huntington
6	Soybeans	30.52	115.00	168.92	-6.35	69.28	120.41	Bruno	Huntington
7	Soybeans	27.05	118.83	172.27	22.76	116.87	169.80	Bruno	Huntington
8	Soybeans	24.39	108.34	168.26	17.19	123.51	188.97	Lily	Wolftever
9	Corn	65.10	156.62	230.94	-23.67	60.22	120.77	Alticrest	Huntington
10	Soybeans	48.44	126.17	194.12	-4.39	83.24	149.56	Litz	Huntington
11	Wheat	-40.93	-15.02	23.34	6.51	82.26	145.64	Lily	Huntington
12	Corn	33.99	106.20	181.94	11.10	92.03	166.91	Litz	Huntington
13	Corn	19.05	98.46	152.21	32.32	119.42	176.87	Litz	Collegedale
14	Corn	29.05	104.62	159.49	2.61	94.32	158.78	Litz	Collegedale

* Source: Dominant in acreage based on the USDA, NASS data, 2005. This excludes hay and tobacco

** Listed in the Appendix

kenaf consistently compete with the dominant crop regions 1, 2, 4, 8, 11 and 13 where the average net return to land and management was higher compared to the dominant crop. Results suggest that kenaf in these regions is potentially feasible to grow as this could provide farmers greater returns than the current crop they are cultivating. However, kenaf was not competitive in regions 3, 5, 6, 7, 9, 10, 12 and 14. Examining the different soils cropped in Tennessee, kenaf net returns obtained in Bruno, Bibb, Lily, Litz and Alticrest soils were generally low while Memphis, Taft, Huntington Wolftever and Collegedale soils generated kenaf highest net returns to land and management.

Table 3 shows the dominant crop in each region, total cultivated land and acres planted to dominant crop and proportions of cropped acres of dominant crop. Across regions of Tennessee, a total of 1,238,873 acres or 18% out of the total 6,992,992 acres were planted to dominant crops.

Proportions of acres planted to dominant crop and the total cultivated land ranged from 3% in regions 9, 11, 13 and 14 to 47% in region 1. This indicates that majority of the cropped acres across regions are cultivated to other crops other than the dominant crop.

Total acres cropped across regions, kenaf potential acreage, total production and acreage percentage are presented in Table 4. Total acres cropped in Tennessee are based on the USDA, NASS database adjusted at county level. If all areas across regions were planted solely to kenaf at the nitrogen base price of $0.38 per pound and kenaf price at $55 per ton, a potential total production of 23,488,018.36 tons would be expected. However, this is not the case because not all cropped areas are planted to single crop by

Table 3. Comparison of total land-based acres, total cropped areas to traditional crops, acres planted to dominant crop and proportions of cropped acres of dominant crop in Tennessee, 2005

Region*	Dominant Crop** in the Region	Total Cultivated Land**	Acres Planted to Dominant Crop***	Proportion of Cropped Acres in Dominant Crop
1	Soybeans	691,144	326,500	47
2	Cotton	660,457	245,000	37
3	Soybeans	834,668	264,500	32
4	Soybeans	435,469	100,100	23
5	Soybeans	326,912	33,766	10
6	Soybeans	274,039	23,333	9
7	Soybeans	743,878	70,567	9
8	Soybeans	838,608	92,900	11
9	Corn	542,296	16,200	3
10	Soybeans	263,200	14,507	6
11	Wheat	175,623	5,734	3
12	Corn	248,756	16,000	6
13	Corn	528,045	16,233	3
14	Corn	429,897	13,533	3
Total		6,992,992	1,238,873	18

* Regional division of Tennessee as shown in Figure 1

** Source: USDA, NASS data

*** Dominant in acreage based on the USDA, NASS Data. This excludes hay and tobacco

Table 4. Comparison of total acres cropped across 14 Tennessee regions, kenaf potential acreage if dominant crop acreage is replaced, potential production and acreage proportions estimated with a nitrogen price at $0.38 per pound and kenaf price at $55 per ton, 2005

Region	Total cultivated land per Region*	Dominant Crop in the Region*	Potential Kenaf Acreage	Total Kenaf Production**	Percent
1	691,144	Soybeans	326,500	5,585,121	47.24
2	660,457	Cotton	101,902	4,095,793	15.43
3	834,668	Soybeans	0	0	31.69
4	435,469	Soybeans	100,100	2,495,137	22.99
5	326,912	Soybeans	7,992	64,381	2.44
6	274,039	Soybeans	0	0	0.00
7	743,878	Soybeans	70,567	4,219,385	9.49
8	838,608	Soybeans	92,900	4,222,542	11.08
9	542,296	Corn	0	0	0.00
10	263,200	Soybeans	0	0.00	0.00
11	175,623	Wheat	5,734	603,054	3.26
12	248,756	Corn	16,000	0	6.43
13	528,045	Corn	16,233	2,202,605	3.07
14	429,897	Corn	0	0	0.00
Total	6,992,992		737,928	23,488,018	

* Source: Dominant in acreage based on the USDA, NASS Data. This excludes hay and tobacco

** Total Production if all were planted to kenaf farmers as this farming practice is typical in many Tennessee counties (Roberts et al., 2005). They cited that crop diversification is used by farmers to decrease production and marketing risk. Nevertheless, production and marketing risk assessment were excluded in this study.

Majority of the acreages of Tennessee devoted to dominant crop production were less than 20% of the total cropped land area except in regions 1, 3, and 4 where parcels of land planted to single crop accounted for 47.2%, 31.69% and 23%, respectively. Assuming farmers were to replace the dominant crop in the regions with kenaf at nitrogen base price of $0.38 per pound and kenaf price at $55 per ton, potential kenaf acreages available would be 737,928 acres or approximately 11% of the total cropped areas in Tennessee.

A breakeven price is calculated by setting the net returns to land and management of kenaf equal to the net returns of dominant crop in the region (Table 5). Across regions, results showed that breakeven price could be as low as $19.75 per ton in region 2 and as high as $74.69 per ton in region 9. The breakeven price on average ranged from $42.00 per ton in region 2 to $69.21 per ton in region 9. Varying results of breakeven was largely dependent on the soil types, optimal nitrogen rates, weather condition, and the net return to land and management of the existing dominant crop in each region. If we are to convince farmers to plant kenaf, average breakeven prices are equal to the minimum price required in the particular region for kenaf to be as economically feasible to produce as the dominant crop. For instance, region 2 requires an estimated kenaf price of $42.00 per ton while region 9 needs a considerably high average price, $69.21 per ton, to breakeven assuming a nitrogen price of $0.38 per pound.

Table 5. Regional breakeven price comparison of Kenaf in Tennessee, 2005

Region*	Total cultivated land per Region**	Dominant Crop in the Region**	Kenaf Breakeven Price ($/ton)		
			Low	Average	High
1	691,144	Soybeans	52.34	53.76	56.59
2	660,457	Cotton	19.75	42.00	55.05
3	834,668	Soybeans	57.75	59.29	60.41
4	435,469	Soybeans	49.50	51.67	53.03
5	326,912	Soybeans	54.21	55.53	57.69
6	274,039	Soybeans	59.06	61.40	62.79
7	743,878	Soybeans	52.61	55.21	58.96
8	838,608	Soybeans	50.65	53.30	57.83
9	542,296	Corn	66.18	69.21	74.69
10	263,200	Soybeans	58.12	60.97	65.98
11	175,623	Wheat	37.11	42.25	51.54
12	248,756	Corn	55.67	56.92	59.47
13	528,045	Corn	50.88	52.45	57.67
14	429,897	Corn	55.08	56.46	60.36

* Regional Division of Tennessee as shown in Figure 1.
** Source: Dominant in acreage based on the USDA, NASS Data. This excludes hay and tobacco

Prices above the average breakeven in each region would generate positive net returns to producers. These results however, assumed that marketing cost of kenaf is equal to that of the dominant crop. Higher marketing cost relative to the identified dominant crop in the region reduces the kenaf competitiveness and hence would increase the prices estimated in the manuscript.

Two-way sensitivity analysis illustrates the impacts of varying variable costs by 5%, 15% and 25% below and above the baseline output price and variable cost on the feasibility of kenaf (Table 6). Results showed that at base price of $55 per ton, an average yield of 7.2 tons per acre and variable cost of $57.00 per acre ceteris paribus, would yield $109.09 per acre net return of kenaf. Nevertheless, when the output price and variable cost was allowed to vary, profits greatly changed. Net return to land and management ranged as low as -$04.16 per acre when the price was reduced by 25% and the variable cost was increased by 25% and as high as $222.34 per acre when output price of kenaf was 25% higher from the baseline and the variable cost was reduced by same percentage.

On the other hand, sensitivity analysis showed that profit of kenaf is not sensitive to changes in variable cost. When variable cost was increased (decreased) by 5%, 15% and 25% from the baseline, kenaf profit expected declines (improves) by only 3%, 7% and 13%, respectively.

Table 6. Profit sensitivity analysis varying the base kenaf output price and variable cost at 5%, 15% and 25% below and 5%, 15% and 25% above the base in Tennessee, 2005

Output Price Price $/ton	Nitrogen Cost ($/ton)						
	-25%	-15%	-5%	Base	5%	15%	25%
-25%	24.34	18.64	12.94	10.09	7.24	1.54	-4.16
-15%	63.94	58.24	52.54	49.69	46.84	41.14	35.44
-5%	103.54	97.84	92.14	89.29	86.44	80.74	75.04
Base	123.34	117.64	111.94	109.09	106.24	100.54	94.84
5%	143.14	137.44	131.74	128.89	126.04	120.34	114.64
15%	182.74	177.04	171.34	168.49	165.64	159.94	154.24
25%	222.34	216.64	210.94	208.09	205.24	199.54	193.84

Figure 1 illustrates the impact in the breakeven variable cost when the base output price of $55 per ton is modified to 25% below and 25% above to get the minimum price of $41 per ton and maximum output price of $77 per ton at 5%-increment holding fixed cost and quantity constant. Relative to changes in output price, results showed that breakeven variable cost is sensitive to changes in output price. As such, variable costs increased proportionately with the increase in output price. This sensitivity to changes of output prices is a crucial factor to decision making among producers because this considerably influenced production output. This suggests that an increase in input prices will reduce input utilization and eventually reduce production output. On the other hand, comparing price variability of kenaf to that of cotton in a narrow market, one could suggest that kenaf price is quite stable and does not vary because of a contract agreement while cotton price may be significantly influenced by quality of the raw materials such color grade, fibers strength and length and uniformity and because it relies on a open market.

Potential kenaf production in Tennessee was examined by varying the price of both the nitrogen applied as ammonium nitrate (+,-50%) and varying the price of kenaf from $40 to $75 per ton (Figures 2, 3, and 4). Reducing the base nitrogen price to $0.19/lb with price below $60 per ton, kenaf was not the profit maximizing crop on most soils throughout Tennessee except in regions 2 and 11 (Figure 2). However, at price $60 per ton or higher, potential supply increased drastically from 64,490 to 5,670,200 tons in all regions except region 9. At this price level, production of kenaf would be economically feasible. Meanwhile, kenaf would be competitive in most regions if the

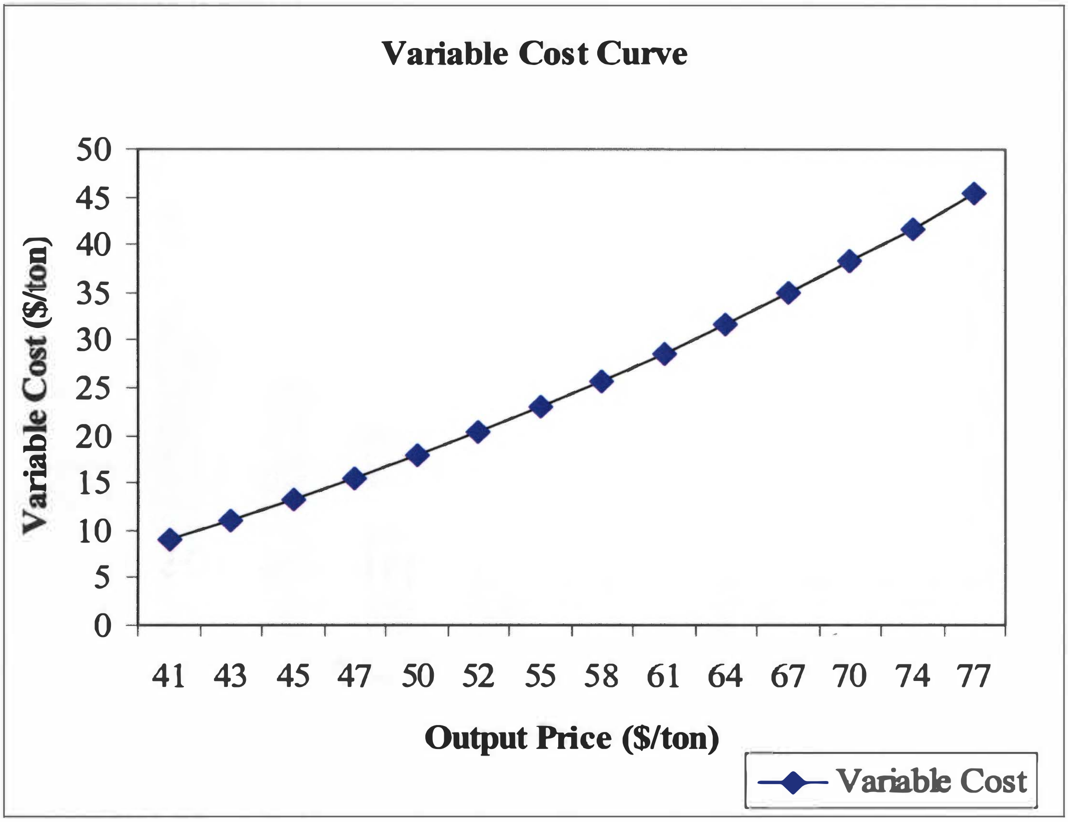

Figure 1. Breakeven variable cost curve for kenaf at 25% below and above the base price of kenaf at $55 per ton at 5% increment in Tennessee, 2005

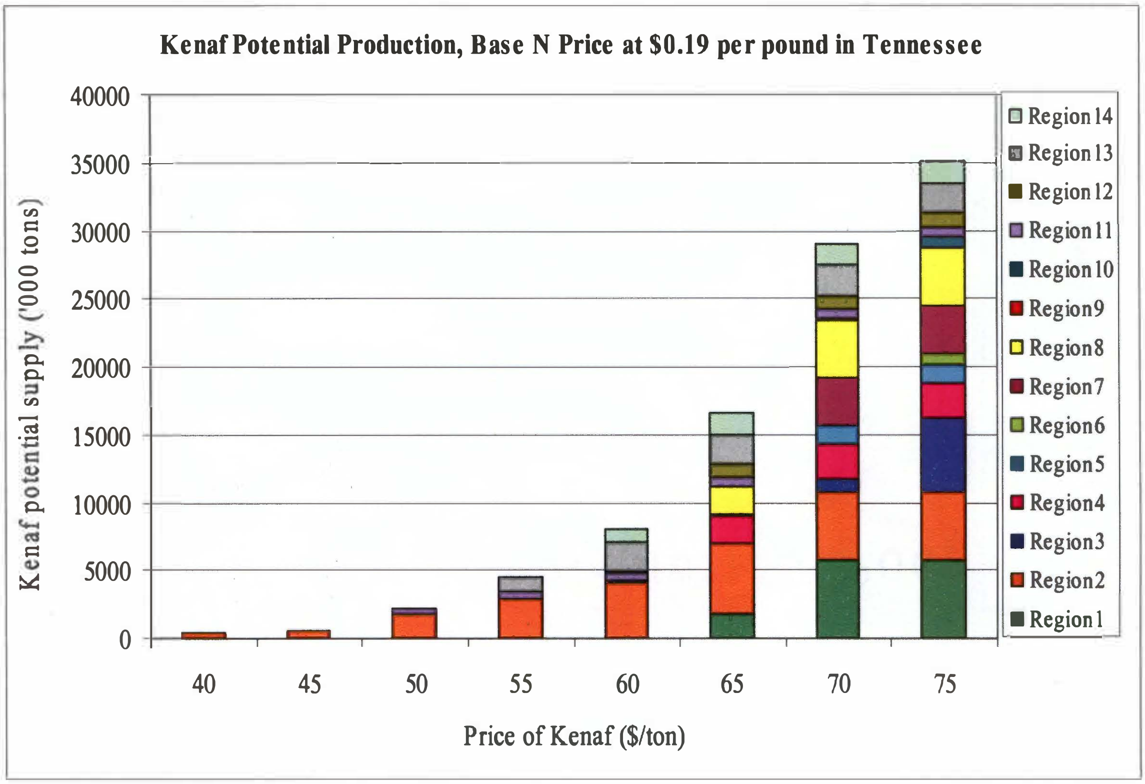

Figure 2. Kenaf potential production, base nitrogen price at $0.19/lb in Tennessee, 2005

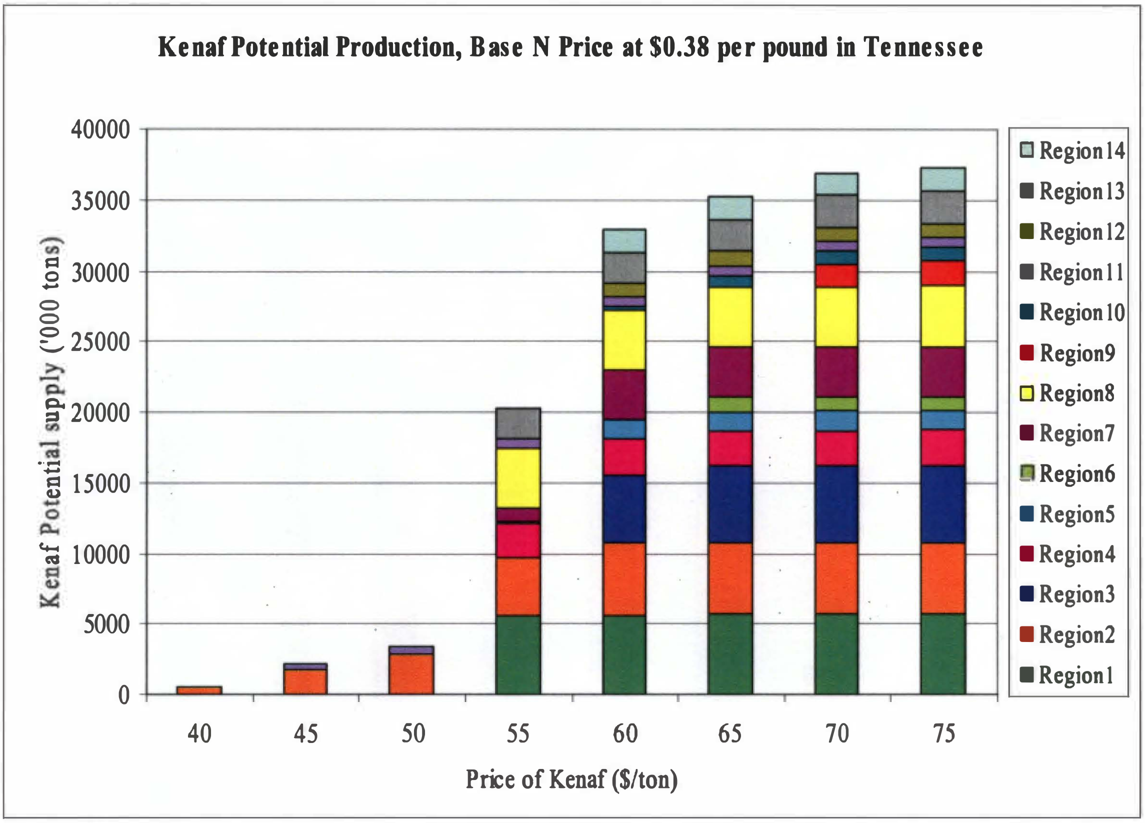

Figure 3. Kenaf potential production, base nitrogen price at $0.38/lb in Tennessee, 2005

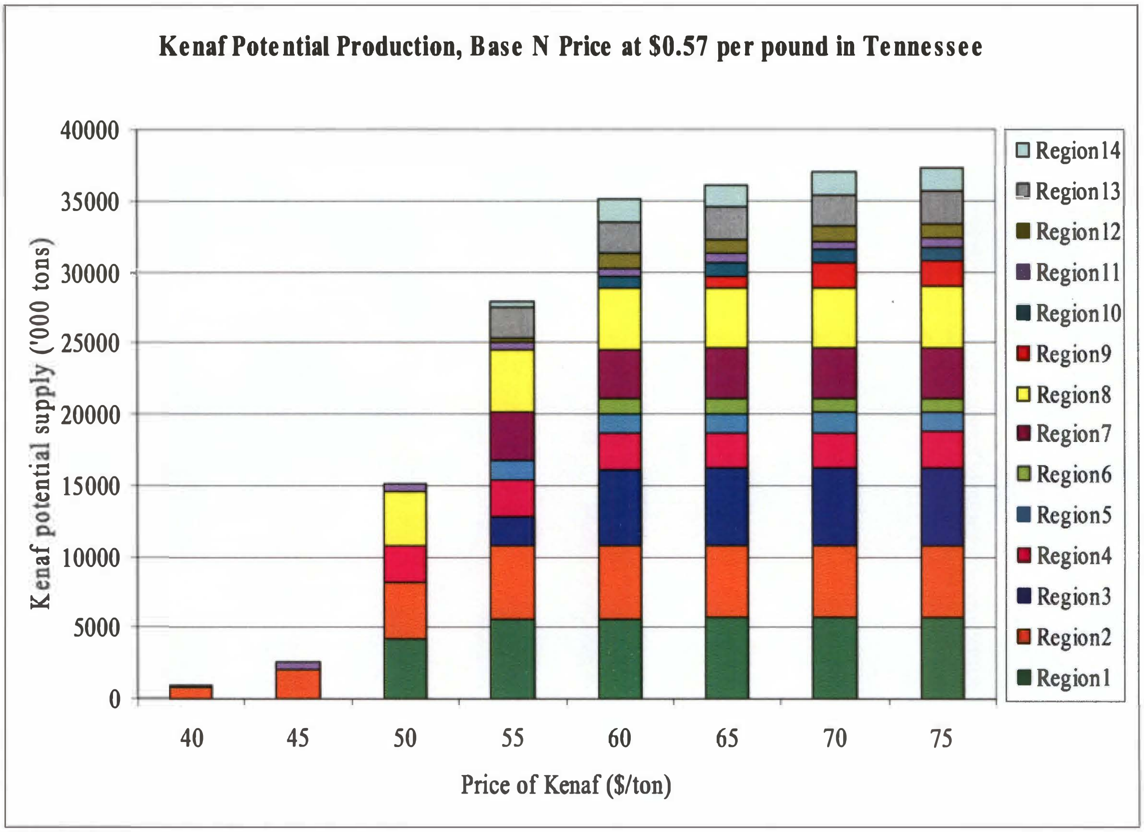

Figure 4. Kenaf potential production, base nitrogen price at $0.57/lb in Tennessee, 2005

base nitrogen price is $0.38/lb and kenaf at $55 per ton price or higher because potential supply increased significantly from 64,380 to 5,670,200 tons (Figure 3).

Increasing the nitrogen price to $0.57/lb from the base price, kenaf resulted in an increase in acreage on across all regions (Figure 4). At price $50 per ton, regions 1, 2, 4, 7 , 8 and 11 may be producing kenaf from 12,190 up to 4,203,240 tons. Results indicated that any price above $50 per ton, kenaf is economically feasible over dominant crop in most regions.

In the above scenarios, when the nitrogen price is increased, crops nitrogen decreases and yields decreases, and subsequently, the net return to land and management decreases. Though results indicate that kenaf yield is reduced as the price of nitrogen increased, its yield reduction rate is slower compared to the dominant crop resulting kenaf becoming the profit maximizing crop in these regions.

Figures 5, 6, and 7 described the potential supply schedule of kenaf at varying prices: $50, $55 and $75 per ton with base nitrogen price of $0.38/lb. This scenario indicates that potential production is expected if the net return to land and management of kenaf is higher than that of the dominant crop in a particular region. Thus, at a specified price level, a profit maximizing producer would be able to produce a certain quantity. When kenaf price is $50 per ton, expected supply in most regions was less than 500,000 tons (Figure 5). At this price level, region 2 has the potential supply ranging from 2 million to 3 million tons while region 11 could potentially provide 0.5 million to 1 million ton.

Increasing the price of kenaf to $55 per ton also increased the forthcoming kenaf supply (Figure 6). At this price level, regions 1, 2 and 8 have a potential production

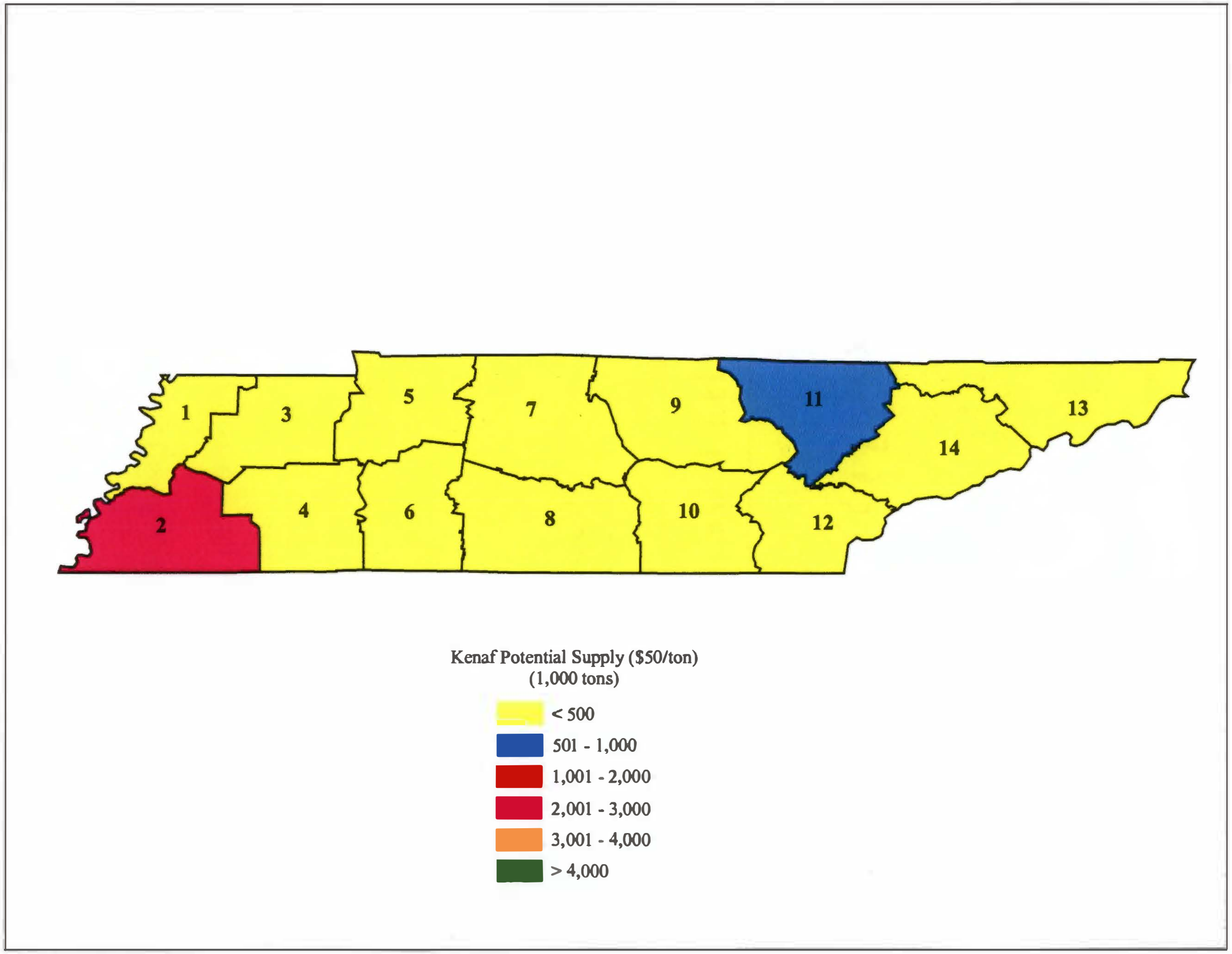

Figure 5. Potential kenaf supply in Tennessee, base nitrogen price at $0.38/lb and kenaf output price at $50 per ton, 2005

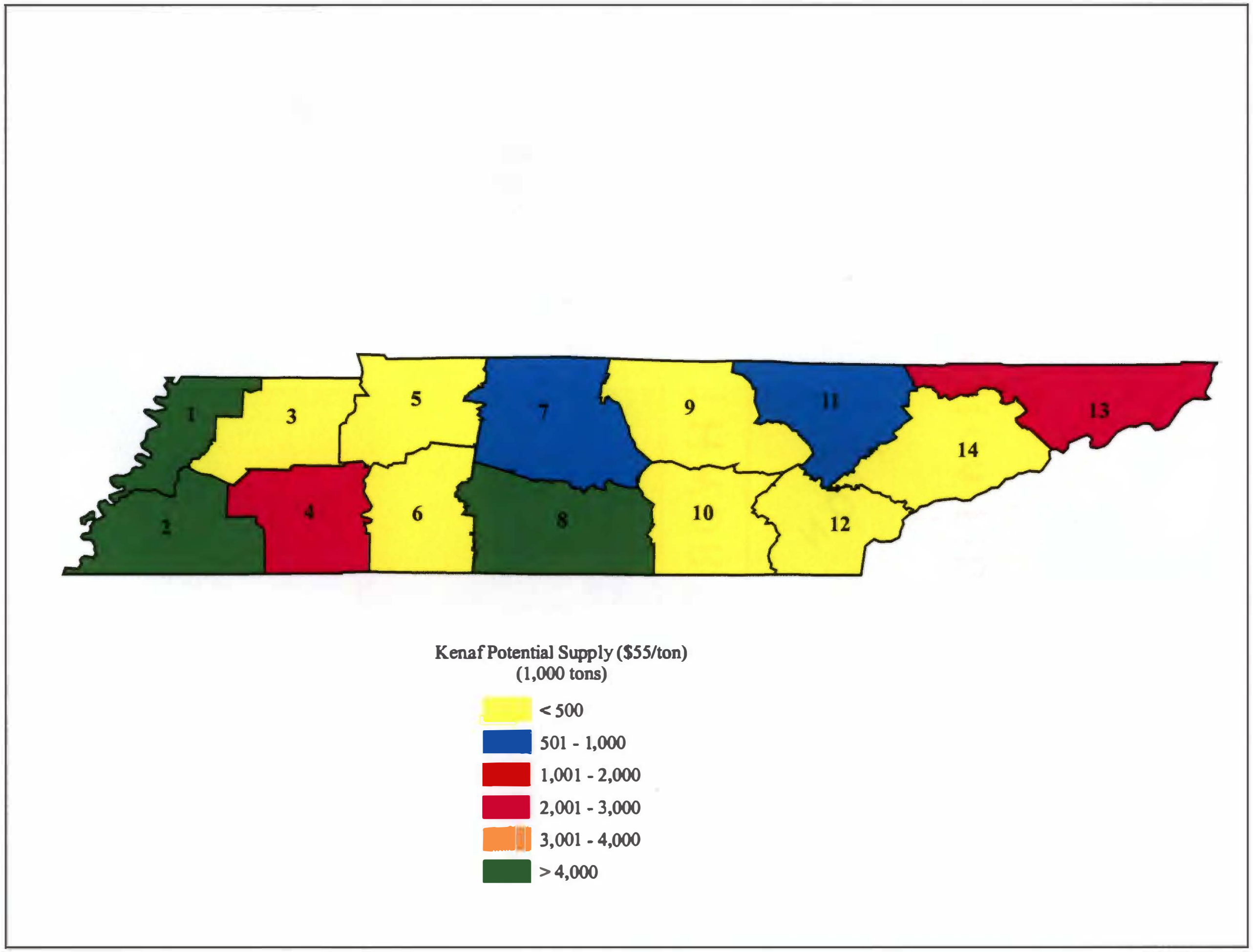

Figure 6. Potential kenaf supply in Tennessee, base nitrogen price at $0.38/lb and kenaf output price at $55 per ton, 2005

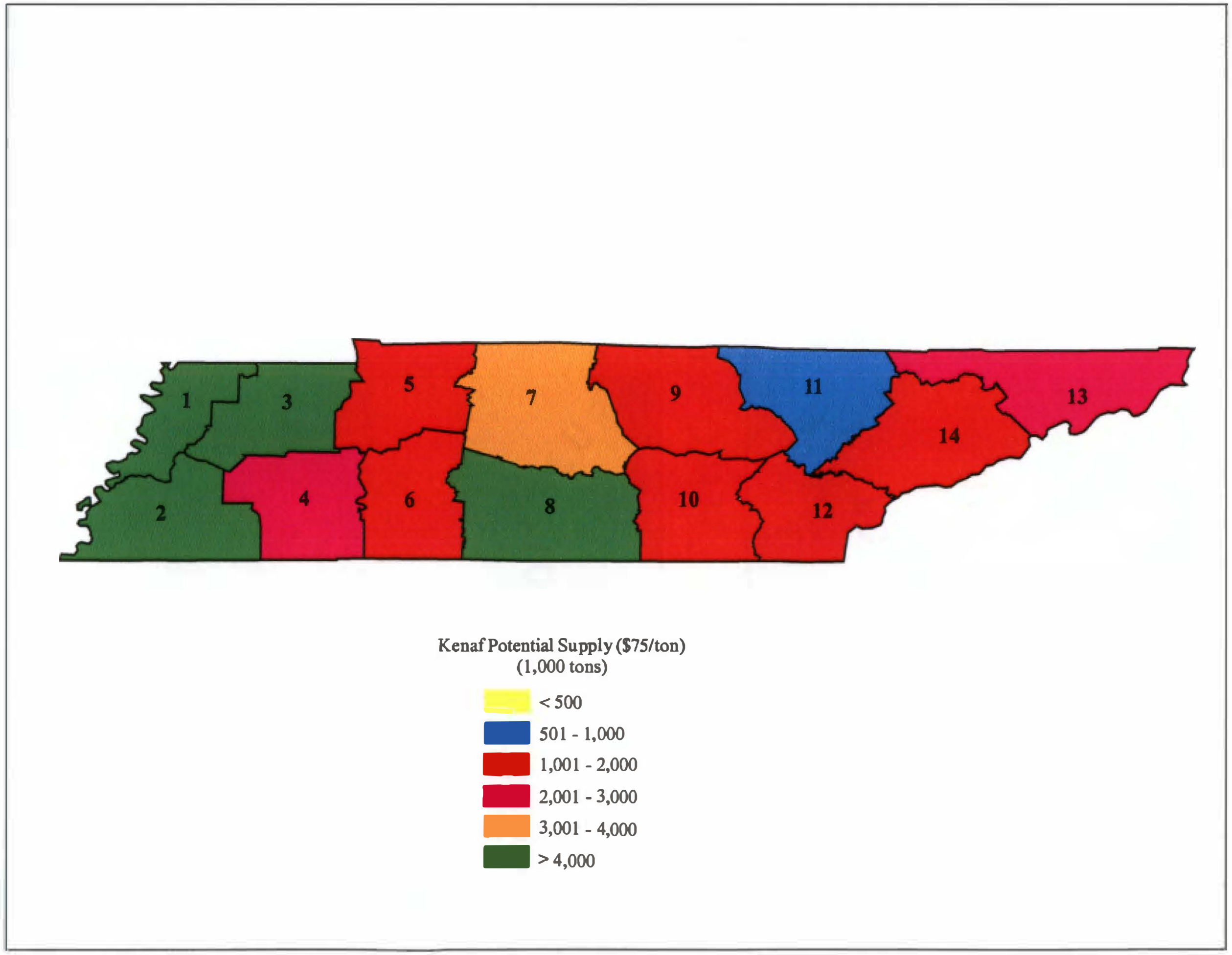

Figure 7. Potential kenaf supply in Tennessee, base nitrogen price at $0.38/lb and kenaf output price at $75 per ton, 2005

exceeding 4 million tons; regions 4 and 13 have the potential supply of ranging from 2 million to 3 million tons; regions 7 and 8 have the potential supply of 0.5 million to 1 million tons. The rest of the regions have a potential supply of less than 0.5 million ton.

On the other hand, at a $75 per ton kenaf output price, the potential supply of kenaf significantly increased (Figure 7). Regions 1, 2, 3 and 8 have a potential supply exceeding 4 million tons; a forthcoming supply in region 7 ranged from 3 million to 4 million tons and regions 4 and 13 have potential supply of kenaf from 2 million to 3 million tons; region 11 has a potential supply from 0.5 million to 1 million ton. Other regions have available potential supply ranging from 1 million to 3 million tons.

Hypothetical farmland consisting of two soils was constructed to provide a better description and understanding on how profit maximizing producers might be able to make investment decisions based on the soil proportions and net return to land and management (Figure 8). In actual field situation, a typical farmland has a mix of different soils. For simplicity, for instance two soil types exist: Bruno and Commerce soils with a $21.30 and $123.91 per acre profit, respectively at a $55/ton kenaf price. The economic decision of the farmer, assuming that market is readily available, is dependent on the proportion of the soil type prevailing in the farm and the possible highest net return obtained. However, when both the net returns and the proportion of soil type increased beyond $82 per acre and 66%, respectively; profit maximizing producers would shift to plant kenaf over soybeans and receive greater profits. This implies that as net returns and soil proportion of the higher profits in soil (Bruno) increased, competitiveness of kenaf also increased. At the equilibrium point, profit maximizing producers were indifferent to either crop because net return to land and management are equal.

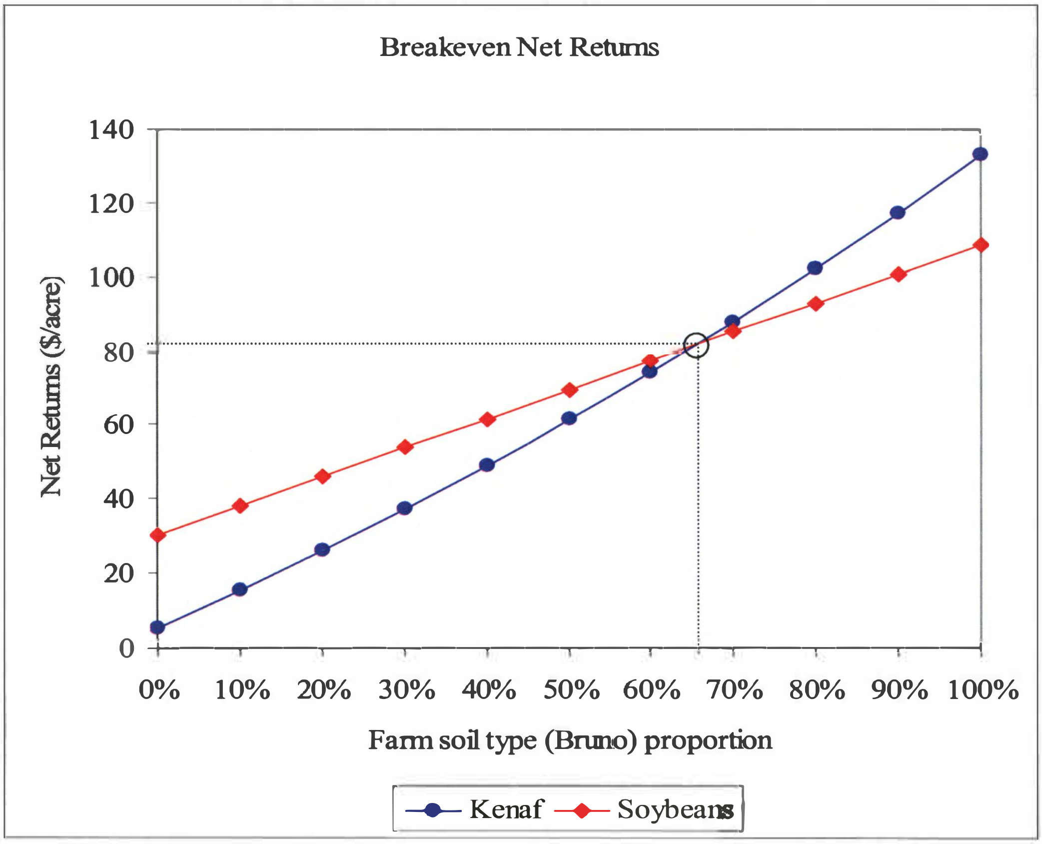

Figure 8. Breakeven net return of kenaf and dominant crop in a hypothetical field situation consisting of two soils: Bruno and Commerce soils, 2005

Conclusion

EPIC simulations were conducted to examine the economic feasibility of kenaf in Tennessee. Profit-maximizing nitrogen fertilization rates and yields were identified for 202 soil types and 14 weather station combination from kenaf meta-yield response functions using the quadratic response functions (QRP). Breakeven and two-way sensitivity analyses were also conducted.

Overall, the net return to land and management suggests that kenaf is potentially suitable for growing in regions 1, 2, 4, 8, and 11 as indicated by higher net return compared to dominant crop. Apparently, kenaf was a profit maximizing crop in regions where cotton and wheat were mostly cultivated. However, it was not competitive in many regions where soybeans and corn thrive. Net returns to land, labor and management reflected assumed that marketing cost of both kenaf and dominant crops are equal. If the cost of marketing kenaf is higher than the dominant crop, its competitiveness is reduced. Take for instance, if the Farm gate price of kenaf is $57.48 per ton on average and the marketing cost is $5 per ton. This makes the effective kenaf farm gate price to reduce by also $5. At this price level, kenaf may not anymore economically feasible to produce over the dominant crop. The difference in the marketing cost affects the expected net return, and would change the potential supply and acreages available for kenaf across regions.

The economic feasibility of producing kenaf across regions was not sensitive to changes in nitrogen prices. As the nitrogen prices were increased (decreased) by 5%, 15% and 25% from the baseline, profitability decreased (increased) by only 3%, 7% and 13%, respectively. Increasing the price of nitrogen, yield of kenaf decreased but on a slower rate than the dominant crop. This leads to increased of kenaf potential acreages across regions relative to the dominant crop.

On the other hand, profitability of kenaf is highly sensitive to changes in output prices. Changing the output price below and above 5%, 15% and 25%, respectively, the corresponding decreased (increased) in profitability was 21%, 54% and 90%. This indicates that output price is a significant decision variable relative to kenaf production.

Breakeven prices varied across regions in reference to the net return to land and management of the dominant crop and the various soil types. Breakeven price ranged from $19.75 per ton in region 2 to $74.69 per ton in region 9. On average, breakeven price was as low as $42.00 per ton and as high as $69.21 per ton. Any price above the indicated average breakeven price in a particular region, kenaf is economically feasible because producers are able to generate positive net returns.

Less than 50% of the cropped lands in Tennessee are cultivated to dominant crops. This is a typical farming practice among farmers in many counties in Tennessee to reduce production and marketing risks (Roberts et al., 2005) of growing agronomic crops including cotton. Nevertheless, production and marketing risks were not accounted for in the analysis. Kenaf market in Tennessee is non-existent. As a new crop to Tennessee without an established market, growing is a risky venture compared to dominant crops. Thus, contract agreements would greatly help in reducing production risk and market uncertainties. It also assures producers and processor of a predictable price and steady supply of raw materials, respectively.

References

American Forest and Paper Association (AF&PA). "Pulp and Paper: Alternative Sources for Paper." 2002. Web accessed on July 12, 2006 at http://www.afandpa.org/Template.cfm?Section=Paper_Products&Template=/ContentManagement/ContentDisplay.cfm&ContentID=7528

Baldwin, B.S. "Growing Kenaf on a Commercial Scale in Mississippi". Dept. of Plant and Soil Sciences, Mississippi State University. 2000. Web accessed on March 15, 2005 at http://www.kenafsociety.org/Abs2000.htm.

Burgess, C. "Kenaf". *Carolina Country*. July 2004, pp 22-23. Web accessed on March 23, 2005 at http://www.carolinacountry.com/storypages/ourstories/kenaf/kenaf.7.04.pdf

Cross, C. "Kenaf – An Alternative Crop for the Tropics". 2005. Web accessed on January 25, 2005 at Http://www.satglobal.com/kenafbas.htm.

Davis, B. "Tree-Free Kenaf Papers". 2003. Web accessed on March 23, 2005 at http://www.visionpaper.com/PDF_speeches_papers/PaperSpecsFinal.pdf.

FAO. "Consultation on Natural Fibers: The Production and Consumption of Kenaf in China." 2003. Site accessed on March 23, 2005 at http://www.fao.org.

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

Hill, S. "Kenaf may be Good Alternative Crop for Rice Belt." 1986. Agricultural Communications, Texas A & M University System. Web accessed on March 24, 2005 at http://www.agnews.tamu.edu/dailynews/stories/SOIL/kenaf.html

Hill, S. "Kenaf Harvest Looks Profitable Despite Wet Weather". 1997. Agricultural Communications, Texas A & M University System. Web accessed on March 24, 2005 at http://www.agnews.tamu.edu.

JCN Network. "NEC Announces Development of High-Strength Highly Heat Resistant Bioplastic: Featuring Polylactic Acid Reinforced with kenaf Fiber." 2003. Web accessed on January 24, 2005 at http://www.japancorp.net/Article.Asp?Art_ID=4708.

Johnson, J. "Alternative Agriculture: What is Kenaf?" Rural Enterprise and Alternative Agricultural Development Initiate Report (Report 1). 2001. Web accessed on March 23, 2005 at http://www.sin.edu/~readi/grains/factsheets/ kenaf.pdf.

Kalo, A., S. B. Sterrett, P.H. Hoepner and D. B. Taylor. "Evaluating the Feasibility of Adopting Kenaf on the Easter Shore of Virginia: Implications for Two Distinct Cropping Systems." Eastern Shore Agricultural Research and Extension Center. VA. 1998 (Abstr). Web accessed on January 24, 2005 at http://www.aaic.org/98progrm3.htm

Kalo, A., S.B. Sterrett, P.H. Hoepner, F. Diem and D.B. Taylor. *Feasibility of Adopting Kenaf on the Eastern Shore of Virginia.* In: Janick (ed), Perspective on new crops and new uses, ASHS Press, Alexandria, V.A. 1999.

Kastens, T.L., K.L. Dhuyvetter, A.L. Schlegel and T.J. Dumler. "Modifying Yield-Goal-Based Fertilizer Recommendations to Reflect Price - A continual presentation." 2005. Web accessed on March 4, 2006 at http://www.agmanager.info/crops/prodecon/production/FertNpaper(Dec2005).pdf.

Hewlett, J.P., R. Kettle and A. Gray. "An Economic Evaluation of the Yield Advantage of Improved Varieties of Alfalfa." University of Wyoming. 1996. Web accessed on May 11, 2006 at http://www.uwyo.edu/ces/PUBS/B1044.pdf.

LeMahieu, P.J., E.S. Oplinger and D.H. Putnam. "Kenaf". Alternative Field Crops Manual. Department of Agronomy, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin – Madison. 1991. Web accessed on August 2, 2005 at http://corn.agronomy.wisc.edu/alternativeCrops/kenaf.htm.

Liu, A. "Making Pulp and Paper from Kenaf." 2002. Web accessed on March 23, 2005 at http://www.Chinaconsultinginc.com/paperpulp.html

Llyod, E.H. and Seber, D. "Bast Fiber Applications for Composites." NetFirms. 1996. Web accessed on August 4, 2005 at http://www.hempology.org/CURRENT%20HISTORY/1996%20HEMP%20COMPOSITES

Ogden, F. Kenaf - The New Paper. *Lessons from the Future*, Vol. 8. 2005. Available at Http://www.drtomorrow.com/lessons/lessons8/15.html. Web accessed on January 24, 2005.

McNulty, S. (Ed). *Report to the Governor's Hemp and Related Fiber Crops Task Force.* 2005. Web accessed on March 23, 2005 at http://www.globalhemp.com.

Motavalli, J. Paper Chase-Continued. *Emagazine.com.* 2004. Web accessed on January 24, 2005 at http://www.emagazine.com/view/?1736.

Nelson, P. "Kenaf and Conservation Tillage: A Natural Economic and Environmental Match Vancil Brothers Farm Grows No-Till kenaf in Southeast Missouri." Agro-Tech Communications. AgFiber Technology News January 19, 1999, Vol.1, No. 2. Web accessed on August 2, 2005 at http://lists.essential.org/ag-res/msg00010.html

Priya, S. and Shibasaki, R. 1998. "National Spatial Crop Yield Simulation using GIS-Based Crop Production Model." Center ofr Spatial Information Science. University of Toky, Tokya, Japan. Web accessed on May 11, 2005 at http://www.csis.u-tokyo.ac.jp/dp/30.pdf

Roberts, R, B.C. English and E.F. Bazen. "Economic Feasibility of Kenaf Production in Three Tennessee Counties." Department of Agricultural Economics, The University of Tennessee, Knoxville, 2005.

Rymsza, T.A. "Creating High Value Markets for Kenaf Paper: A Commercial Experience." Paper presented at the First Annual Conference of the American Kenaf Association, San Antonio, TX, 28 February 1998. Web accessed on March 24, 2005 at http://www.visionpaper.com/PDF_speeches_papers/982aks.pdf

Rymsza, T.A. "Utilization of kenaf Raw Materials. Forest Products Society." Paper presented at Forest Products Society, Boise, Idaho, 30 June 1999. Web accessed on March 23, 2005 at http://www.visionpaper.com.

Rymsza, T.A. "Kenaf and Hemp, Appropriateness Analysis for Paper Production." Paper presented at the 3rd Annual Conference of American Kenaf Society, Corpus Christi, TX, 24-26 February 2000. Web accessed on March 15, 2005 at http://www.kenafsociety.org/Abs2000.htm.

Stier, C., W. Steele and J. Engelhard. "Pulpwood Procurement Practices in the Wisconsin-Upper Michigan Pulp and Paper Industry." *Northern Journal of Applied Forestry,* Volume 3, Number 1, 1 March 1986, pp. 10-14(5). Web accessed on July 10, 2006 at http://utk.library.ingentaconnect.com/content/saf/njaf/1986/00000003/00000001/art00005

Taylor, C.S. New Crop Factsheets. 1995. Web accessed on March 24, 2005 at http://www.hort.purdue.edu/newcrop/cropfactssheets/kenaf.html.

The Vaults of Erowid. "Facts About Kenaf Paper." 2003. Web accessed on November 29, 2004 at http://www.erowid.org/plants/cannabis/hemp/hemp_info2.shtml.

New Crop Opportunities Center. "Kenaf." College of Agriculture Cooperative Extension Service, University of Kentucky. 2005. Web accessed on March 24, 2005 at http://www.uky.edu/Ag/NewCrops/introsheets/kenafintro.pdf

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

Valigra, L. "Tough as Soybeans: The Long Search for Plants with Optimal Material Properties Starts to Pay Off." Global Hemp. 2000. Web accessed on January 24, 2005 at http://www.global hemp.com/Archives/Magazines/tough-as_soyben.html.

Webber, C.L. III, V.K. Bledsoe, and R.E. Bledsoe. 2002. *Kenaf Harvesting and Processing*. 9. 340-347. In (J. Janick and A. Whipkey, eds), Trends in new crops and new uses. ASHS Press, Alexandria, V.A. Web accessed on June 30, 2005 at http://www.hort.purdue.edu/newcrop/ncnu02/v5-340.html.

Wood, I. M. and de Jong, S. "Plant Fiber Crops." The New Rural Industries: A handbook for Farmers and Investors. Rural Industries Research & Development Corporation, Australia. 2000. Web accessed on August 16, 2005 at http://www.rirdc.gov.au/pub/handbook/plantfibre.html

Wright, L.L., M.A. Walsh, M.E. Downing, L.A. Kszos, J.H. Cushman, G.A. Tuskan, S.B. McLaughlin, V.R. Tolbert, J. Scurlock, J. and A.R. Ehrenshaft. "Biomass Feedstock Research and Development for Multiple Products in the United States." Paper presented at the 1st World Conference and Exhibition on Biomass for Energy and Industry, a joint millennium event of the 11th European Conference on Biomass for Energy and Industry and the Biomass Conference of the Americas, Conference and Exhibition Centre, Sevilla, Spain, June 5 - 9, 2000.

APPENDIX

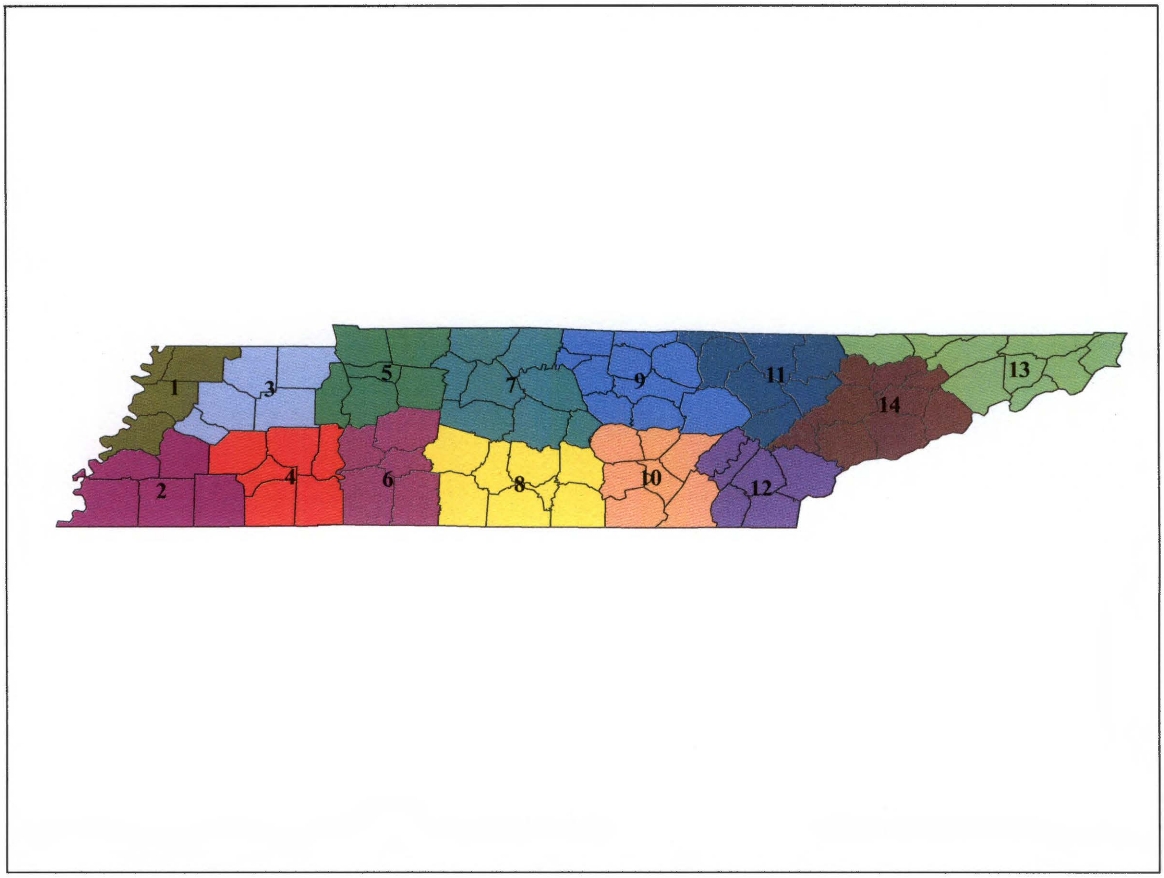

Figure A.1 Regional Map of Tennessee, 2005

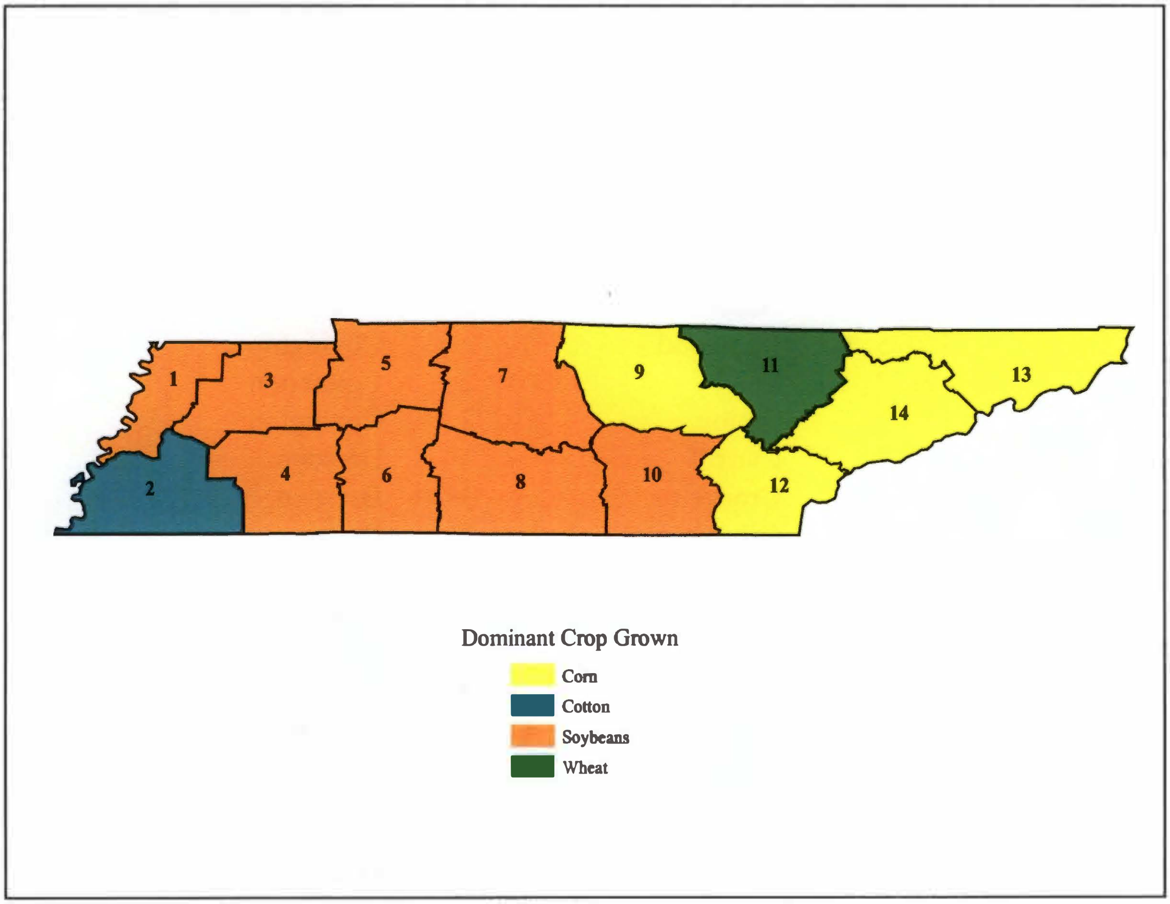

Figure A.2. Dominant crops grown based on acreage planted across regions of Tennessee, 2005

Table A.1. List of different counties in Tennessee comprising each region based on weather station, 2005

State	StcntyFIPS	County	Region	Weather Station
TN	47045	Dyer	1	Samburg Wildlife Rfg
TN	47095	Lake	1	Samburg Wildlife Rfg
TN	47097	Lauderdale	1	Samburg Wildlife Rfg
TN	47131	Obion	1	Samburg Wildlife Rfg
TN	47047	Fayette	2	Covington
TN	47069	Hardeman	2	Covington
TN	47075	Haywood	2	Covington
TN	47157	Shelby	2	Covington
TN	47167	Tipton	2	Covington
TN	47017	Carroll	3	Dresden
TN	47033	Crockett	3	Dresden
TN	47053	Gibson	3	Dresden
TN	47079	Henry	3	Dresden
TN	47183	Weakley	3	Dresden
TN	47023	Chester	4	Lexington
TN	47039	Decatur	4	Lexington
TN	47071	Hardin	4	Lexington
TN	47077	Henderson	4	Lexington
TN	47113	Madison	4	Lexington
TN	47109	McNairy	4	Lexington
TN	47005	Benton	5	Dover
TN	47043	Dickson	5	Dover
TN	47083	Houston	5	Dover
TN	47085	Humphreys	5	Dover
TN	47125	Montgomery	5	Dover
TN	47161	Stewart	5	Dover
TN	47081	Hickman	6	Centerville
TN	47099	Lawrence	6	Centerville
TN	47101	Lewis	6	Centerville
TN	47135	Perry	6	Centerville
TN	47181	Wayne	6	Centerville
TN	47015	Cannon	7	Springfielf Exp Station
TN	47021	Cheatham	7	Springfielf Exp Station
TN	47037	Davidson	7	Springfielf Exp Station
TN	47147	Robertson	7	Springfielf Exp Station
TN	47149	Rutherford	7	Springfielf Exp Station
TN	47165	Sumner	7	Springfielf Exp Station
TN	47187	Williamson	7	Springfielf Exp Station
TN	47189	Wilson	7	Springfielf Exp Station

Table A.1...Continued

State	StcntyFIPS	County	Region	Weather Station
TN	47003	Bedford	8	Shelbyville
TN	47031	Coffee	8	Shelbyville
TN	47051	Franklin	8	Shelbyville
TN	47055	Giles	8	Shelbyville
TN	47103	Lincoln	8	Shelbyville
TN	47117	Marshall	8	Shelbyville
TN	47119	Maury	8	Shelbyville
TN	47127	Moore	8	Shelbyville
TN	47027	Clay	9	Cookeville
TN	47035	Cumberland	9	Cookeville
TN	47041	DeKalb	9	Cookeville
TN	47087	Jackson	9	Cookeville
TN	47111	Macon	9	Cookeville
TN	47133	Overton	9	Cookeville
TN	47141	Putnam	9	Cookeville
TN	47159	Smith	9	Cookeville
TN	47169	Trousdale	9	Cookeville
TN	47185	White	9	Cookeville
TN	47007	Bledsoe	10	Pikeville
TN	47061	Grundy	10	Pikeville
TN	47065	Hamilton	10	Pikeville
TN	47115	Marion	10	Pikeville
TN	47153	Sequatchie	10	Pikeville
TN	47175	Van Buren	10	Pikeville
TN	47177	Warren	10	Pikeville
TN	47001	Anderson	11	Allardt
TN	47013	Campbell	11	Allardt
TN	47049	Fentress	11	Allardt
TN	47129	Morgan	11	Allardt
TN	47137	Pickett	11	Allardt
TN	47145	Roane	11	Allardt
TN	47151	Scott	11	Allardt
TN	47011	Bradley	12	Athens
TN	47107	McMinn	12	Athens

Table A.1…Continued

State	StcntyFIPS	County	Region	Weather Station
TN	47121	Meigs	12	Athens
TN	47123	Monroe	12	Athens
TN	47139	Polk	12	Athens
TN	47143	Rhea	12	Athens
TN	47019	Carter	13	Bristol
TN	47025	Claiborne	13	Bristol
TN	47059	Greene	13	Bristol
TN	47067	Hancock	13	Bristol
TN	47073	Hawkins	13	Bristol
TN	47091	Johnson	13	Bristol
TN	47163	Sullivan	13	Bristol
TN	47171	Unicoi	13	Bristol
TN	47179	Washington	13	Bristol
TN	47009	Blount	14	Jefferson City
TN	47029	Cocke	14	Jefferson City
TN	47057	Grainger	14	Jefferson City
TN	47063	Hamblen	14	Jefferson City
TN	47089	Jefferson	14	Jefferson City
TN	47093	Knox	14	Jefferson City
TN	47105	Loudon	14	Jefferson City
TN	47155	Sevier	14	Jefferson City
TN	47173	Union	14	Jefferson City

Table A.2. Soils in Tennessee used in EPIC runs with hydrologic group (HG), 2005

Soil Name	HG	Soil Name	HG	Soil Name	HG
ADATON	D	CHRISTIAN	C	FORESTDALE	D
ADLER	C	CLAIBORNE	B	FRANKSTOWN	B
ALCOA	B	CLARKRANGE	C	FREDERICK	B
ALLEN	B	CLARKSVILLE	B	FULLERTON	B
ALTAVISTA	C	CLIFTON	B	GILPIN	C
ALTICREST	B	CLOUDLAND	C	GODWIN	D
APISON	B	COLBERT	D	GREENDALE	B
ARKABUTLA	C	COLLEGEDALE	C	GRENADA	C
ARMOUR	B	COLLINS	C	GRIGSBY	B
ARRINGTON	B	COMMERCE	C	GROSECLOSE	C
ASHWOOD	C	CONASAUGA	C	GUTHRIE	D
ASKEW	C	CONGAREE	B	HAGERSTOWN	B
ATKINS	D	CONVENT	C	HAMBLEN	C
BARBOURVILLE	B	COTACO	C	HAMMACK	B
BAXTER	B	CRIDER	B	HAMPSHIRE	C
BEASON	C	CROSSVILLE	B	HARPETH	B
BELLAMY	C	CUMBERLAND	B	HARTSELLS	B
BEWLEYVILLE	B	DECATUR	B	HAYESVILLE	B
BIBB	D	DELLROSE	B	HAYTER	B
BIRDS	C/D	DEWEY	B	HENDON	C
BOWDRE	C	DICKSON	C	HENRY	D
BRADDOCK	B	DUBBS	B/C	HIWASSEE	B
BRADYVILLE	C	DULAC	C	HOLSTON	B
BRANDON	B	DUNDEE	C	HUMPHREYS	B
BRAXTON	C	DUNMORE	B	HUNTINGTON	B
BRUNO	A	DUNNING	D	IUKA	C
BYLER	C	EAGLEVILLE	D	JEFFERSON	B
CALLOWAY	C	EGAM	C	KEYESPOINT	D
CALVIN	C	ELK	B	LAWRENCE	C
CANNON	B	EMORY	B	LAX	C
CAPSHAW	C	ENNIS	B	LEADVALE	C
CAPTINA	C	ENVILLE	C	LEE	D
CARBO	C	ETOWAH	B	LEXINGTON	B
CENTER	C	FALAYA	D	LILY	B
CHAGRIN	B	FALKNER	C	LINDELL	C
CHENNEBY	C	FARRAGUT	C	LINDSIDE	C

Table A.2…Continued

Soil Name	HG	Soil Name	HG	Soil Name	HG
LINKER	B	POPE	B	TASSO	B
LITZ	C	POYNOR	B	TATE	B
LOBDELL	B	PROVIDENCE	C	TELLICO	B
LOBELVILLE	C	PRUITTON	B	TIMBERVILLE	B
LOMOND	B	PURDY	D	TIPPAH	C
LONEWOOD	B	REELFOOT	C	TOOTERVILLE	D
LORING	C	ROBERTSVILLE	D	TOWNLEY	C
LUVERNE	C	ROELLEN	D	TRANSYLVANIA	B
LYERLY	D	ROME	B	TRIMBLE	B
LYNNVILLE	C	ROUTON	D	TUPELO	D
MANTACHI	C	RUSTON	B	TUSQUITEE	B
MASADA	C	SAFFELL	B	TYLER	D
MAURY	B	SANGO	C	VACHERIE	C
MELVIN	D	SAVANNAH	C	VERTREES	B
MEMPHIS	B	SENSABAUGH	B	VICKSBURG	B
MIMOSA	C	SEQUATCHIE	B	WAX	C
MINVALE	B	SEQUOIA	C	WAYNESBORO	B
MONONGAHELA	C	SEWANEE	B	WELCHLAND	B
MOUNTVIEW	B	SHACK	B	WHITESBURG	C
MUSE	C	SHARKEY	D	WHITWELL	C
MUSKINGUM	C	SHELOCTA	B	WILCOX	D
NAUVOO	B	SHOTTOWER	B	WOLFTEVER	C
NESBITT	B	SHOUNS	B		
NEUBERT	B	SHUBUTA	C		
NEWARK	C	SILERTON	B		
NICHOLSON	C	SINDION	B		
NOAH	B	SMITHDAL	B		
NOLICHUCKY	B	STASER	B		
NOLIN	B	STATLER	B		
OCANA	B	STEENS	C		
OCHLOCKO	B	STIVERSVILLE	B		
OKTIBBEHA	D	SUGARGROVE	B		
PADEN	C	SULLIVAN	B		
PEMBROKE	B	TAFT	C		
PHILO	B	TALBOTT	C		
PICKWICK	B	TARKLIN	C		

Table A.3. Kenaf, No-tillage, Farm-Gate Budgets, (38-inch rows), Estimate Costs and Returns per Acre, (12/16-row equipment, 2005

Item	Description	Unit	Qty	Price ($)	Amount ($)
Revenue					
kenaf	Stocks	Ton	7.20*	55.00	396.00
Variable Expenses					
Seed	6.6 lb/acre (8.5 seed/ft)	lb	6.60	3.00	19.80
Fertilizers					
N	N applied as AN	lb	150.00*	0.38	57.00
P_2O_5		lb	60.00	0.28	16.80
K_2O		lb	90.00	0.13	11.70
Custom Application[a]	Tenn Farm Coop.	Ac	1.00	4.00	4.00
Herbicides					
Burndown	Generic Glyphosate	Gal	0.21	16.00	3.37
	2,4-D for Resistant Horseweed	Pt	1.00	1.81	1.81
Pre-emergence	Gramoxone Max	Pt	2.20	4.62	10.16
	Prowl	Qt	1.50	5.38	8.07
Post-emergence	Staple	Oz	1.20	19.10	22.92
	Surfactant	Qt.	0.08	3.50	0.29
Machinery Repair		Ac	1.00	3.23	3.23
Machinery Fuel		Ac	1.00	1.05	1.05

Table A.3… Continued

Item	Description	Unit	Qty	Price ($)	Amount ($)
Custom Harvesting		Ac	1.00	45.37	45.37
Operating Capital	Six Months	Ac	205.58	0.08	8.22
				Total Variable Expenses	213.80
				Return Above Variable Expenses	182.20
Machinery Fixed Expenses					
Production		Ac	1.00	7.36	7.36
Harvesting[b]		Ac	1.00	59.57	59.57
				Total Machinery Fixed Expenses	66.93
				Return to Land, Labor, Mgt, and risk	115.27
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, Mgt, and Risk	109.09

[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.

[c] Includes labor for operating tractors to pull boll buggies and create modules. Custom harvesting charge includes labor to operate silage harvester.

* Varies depending on the optimal nitrogen required and yield level in each soil, respectively.

Source: Roberts et al. (2005). Economic Feasibility of Kenaf Production in Three Tennessee Counties, University of Tennessee, Knoxville.

58

Table A. 4. Machinery operations and requirements for kenaf production in Tennessee, 2005

Operation	Machine Hours/Acre	Labor Hours/Acre	Machinery Requirements
Plant	0.06	0.0750	215 Hp Tractor, 12 row No-till planter
Spray Burndown	0.01	0.0125	16-row self-propelled sprayer
Spray Pre-emergence	0.01	0.0125	16-row self-propelled sprayer
Spray Post-emergence	0.01	0.0125	16-row self-propelled sprayer

Source: Roberts et al. (2005). Economic Feasibility of Kenaf production in Three Tennessee Counties, University of Tennessee, Knoxville.

Table A.5. Machinery and Labor costs per acre for kenaf production in Tennessee, 2005

		Machinery					Total
	Labor	Fixed Cost			Variable Cost		Machinery
Item	Cost	Machinery	Interest	Total	Repair	Fuel	Cost
		---------------------($/Acre) ---------------------					
215 Hp Tractor	0.6	0.6	0.43	1.03	0.59	0.71	2.33
16-Row Self-Propelled sprayer	0.3	2.21	1.36	3.57	1.35	0.34	5.26
12-row No-till planter	N/A	1.75	1.02	2.77	1.29	N/A	4.96
Total	0.9	4.55	2.81	7.36	3.23	1.05	11.64

N/A = Not Applicable

Source: Roberts et al. (2005). Economic Feasibility Kenaf Production in Three Tennessee Counties, University of Tennessee, Knoxville.

Table A.6. Returns to land and management for farm-gate kenaf production with base yield of 7.2 tons per acre and base price of $55 per ton, 2005

Price	kenaf produced in tons per acre						
	2.00	4.00	6.00	7.20	8.00	10.00	12.00
($/ton)			($/Acre)				
40.00	-206.31	-126.31	-46.31	1.69	33.69	113.69	193.69
45.00	-196.31	-106.31	-16.31	37.69	73.69	163.69	253.69
50.00	-186.31	-86.31	13.69	73.69	113.69	213.69	313.69
55.00	-176.31	-66.31	43.69	109.69	153.69	263.69	373.69
50.00	-186.31	-86.31	13.69	73.69	113.69	213.69	313.69
65.00	-156.31	-26.31	103.69	181.69	233.69	363.69	493.69
70.00	-146.31	-6.31	133.69	217.69	273.69	413.69	553.69
75.00	-136.31	13.69	163.69	253.69	313.69	463.69	613.69

Source: Roberts et al. (2005). Economic Feasibility of Kenaf production in Three Tennessee Counties, University of Tennessee, Knoxville.

Table A.7. Break-even kenaf prices for kenaf yields ranging from 2 tons per acre to 12 tons per acre with a base yield of 7.2 tons per acre, 2005

kenaf Yield (tons/acre)	Break-even kenaf Price
2.00	143.16
4.00	71.58
6.00	47.72
7.20	39.77
8.00	35.79
10.00	28.63
12.00	23.86

Source: Roberts et al. (2005). Economic Feasibility of Kenaf Production in Three Tennessee Counties, University of Tennessee, Knoxville.

Part III: Marketing of Kenaf in the State of Tennessee

Introduction

Kenaf is relatively a potential crop to emerge in Tennessee marketplace. Interest in the production of kenaf in Tennessee has risen recently because of several influential factors such interests in the South as a production area by foreign investors, concerns over decreasing pulp supplies, as well as government and consumer demand on the tobacco industry (Nelson and Cook, 1998). Furthermore, the United States Department of Agriculture-Agricultural Research Service (ARS) (2005) found that U.S. farmers could plant kenaf in place of corn, soybeans, cotton, or rice. However, ARS added that such a change depends on the magnitude of economic return that farmers get out of their investment. Kenaf must be grown in a cropping system where it can produce sufficient yields to compete economically with other crops (Taylor, 1984). Small and medium-sized pulp mills can be situated near the kenaf farms to take ready advantage of the fiber (Rethinkpaper, 2006). Entrepreneurs need to persuade industrial customers to purchase the product but those industrial customers who are convinced want large volumes and that requires convincing farmers to rapidly expand the supply.

Marketing is a vital component to a successful commercialization because it encompasses all aspects of operations and decisions of producers. It is defined as the process of planning and executing the pricing, promotion, and distribution of goods, ideas, and services to create exchanges that satisfy individual and organizational goals (Wikipedia, 2005).

One of the most important deciding factors for kenaf commercialization is market development, and the availability of nearby kenaf processing plants. Successful commercialization is dependent on local cost comparisons which will consider economies of scale, transportation and local processor demand (LeMahieu et al., 1991). The proximity of growers to potential processors is the key to economic advantage for the new crop (Roseberg, 1996). However, buyers must be assured of good quality and a year-round supply of crop.

The objectives of the paper were to identify potential kenaf marketing structure and marketing channels in the state of Tennessee, and to identify potential marketing problems of kenaf. Descriptive analysis was used in the analysis using the Strategic marketing management model. Results of this study will help farmers, cooperatives and/or association, potential investors, policy planners, financial institutions and extension agents understand the relevant issues related to the marketing of kenaf and agribusiness decision-making.

Related Literature

The increased diversity of harvesting and processing methods reinforced the possible areas for kenaf development. In many instances, however, the barrier to commercialization is management and availability of resources with which to link agriculture production to the processing and marketing sector (O'Connell, 1990). To effect commercialization of kenaf, there is a need to focus on product applications and marketing using kenaf fibers (Taylor, 1995). With an assured market, kenaf might be less risky to grow than "seed crops" like rice or corn because only the stalk is marketed (Hargrove, 1997). Today, through cooperative agreements with private firms, kenaf is poised to make the leap from the laboratory to full-scale production (USDA, 2005).

In Thailand, recent evidence showed that contract farming can be a vehicle for intensification of agricultural production and expansion of agro-industry (Wiboonpoongse et al., 1998). Wiboonpoongse et al. (1998) added that there should be collaboration among agricultural extension agents, agricultural banks and cooperatives to reduce price risks, market uncertainty and improve farmers' technical knowledge. Omahen (2001) indicated that farmers in Georgia know how to grow kenaf but do not have solid marketing program for selling it. Sullivan (2003) reported that commercial markets are expanding and most acreage is contract-grown and consequently, there is no open market price for kenaf. Taylor (1984) cited that contract growing that guarantee crop's market seemed to be the way to finance kenaf production. Such agreements enable farmers to attain financial assistance from commercial lending institutions. He said that there must be some assurance from the market before banks will assist in the financing. Rymza (2001) cited that any kenaf pulp mill project must appear attractive to the financing community and that the cost of producing a ton of pulp must be lower than the cost of producing a ton of tree based pulp. He added that to perform long term financial projections, raw material availability must be guaranteed, and the price must be predictable. On the other hand, pulpwood is typically procured through direct contract agreements with producers and tapered integration to provide sufficient inventories of raw materials to processors (Stier et al., 1986).

Alternatively, mills could provide seeds and fertilizers (Taylor, 1984) with the costs of these inputs reflected on the contract price. Furthermore, Taylor (1984) cited that farmers will grow kenaf if mills will purchase it at the right price and publishers will buy kenaf newsprint if the quality and price are right. As with many processed food crops, the actual price that producers receive for raw product will likely be determined through contract negotiation between the growers and the processors (LeMahieu et al., 1991). That price must consider production costs, the comparable risks and profits of producing dominant crops and the comparable prices paid by potential customers for traditional fiber supplies. Burgess (2004) suggested that kenaf growers and their business partners must employ a bottom-up farming approach: Grow the crop, process, and develop markets of the product. However, Motavalli (2004) found that kenaf could become a major fiber crop in the United States but efforts to establish a dedicated newsprint pulp mill have so far stalled because of inadequate financing.

Taylor (1984) described that for mills to be assured of a reliable year-round supply, a kenaf procurement system must be created. A grading system incorporating the appropriate moisture content, level of contaminants like weeds and dirt, and the color of harvested kenaf should be developed since these characteristics directly affect paper quality. Webber and Bishop (1998) noted that the expansion of the commercial industry using fiber from kenaf will encompass the management of production, harvesting, processing and market system combined with directed research, focused development and communication among a diverse constituents working closely for economic development.

The kenaf-newsprint system, the newspaper publishers occupy a key position (Taylor, 1984). Although they do not grow or pulp kenaf, they provide the final market. Their influence on the suppliers of their newsprint will be a major factor in putting the system together. Nonetheless, he found out that major constraint in the marketing system appears to be the present reluctance of the paper industry to make changes requiring large capital expenditures. In addition, paper makers are also uncertain about the dependability of kenaf supplies due to its seasonal harvest. Thus, storage arrangement is necessary. Recently, Mississippi State has developed new storage technology that may solve the storage problem (The Carbohydrate Economy, 1998).

McConnell (1995) conducted a case study on commercialization of tea tree oil in Australia using the Strategic Marketing Management (SMM) model. He cited that this tool has a considerable advantage over other techniques used (Delphi, PMC, Political intervention and recreational method) in the commercialization of new crop such as kenaf. This model has the ability to identify critical marketing factors that could either impede or accelerate new crop commercialization. As a tool, SMM helped decision makers create a road map business overall direction and strategies focused on customers satisfaction and potential competitors. Particularly, it helped evaluate the performance of the firm and set priorities for changes in operation. Findings of the study indicated that sound management by industry pioneers, location, timing, and low technological requirements were critical factors leading to successful commercialization.

Methodology

To examine the marketing potential of kenaf in Tennessee, a number of steps were taken. Existing marketing structures were reviewed particularly on crops like hay, tomatoes, cotton and pulpwood because their characteristics and/or marketing practices may closely resemble that of a kenaf market. Feasible marketing arrangements for kenaf were then examined. Finally, a Strategic Marketing Management (SMM) model was constructed that assessed the potential of kenaf in Tennessee marketplace.

As indicated in the introduction, cooperative contract growing can be one of the most effective methods for kenaf market because this assured farmers and processors of the prices they received after harvest and sufficient required volume of supply. However, aside from cooperative contract growing, other potentially viable marketing arrangements were also assessed like direct marketing and brokers' markets. Likewise, basic types of market structures such as monopoly and oligopoly (supply side), and monopsony and oligopsony (buying side) were reviewed to present a better scenario for kenaf market.

The Strategic Marketing Management (SMM) model incorporated Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis and Porter's Five Competitive Forces to assess the potential of kenaf in Tennessee marketplace. This analysis provides relevant information related to kenaf competitiveness in the industry. Because of the data limitation related to marketing of kenaf, a descriptive analysis was applied in the overall discussion using basic economic theories and marketing principles.

Results and Discussion

1. Industry Situation

U.S. per capita consumption of paper is more than 700 pounds approximately two pounds per person per day (Engel, 1997) and demand for newsprint and paper continue to expand by 43 percent since the 1980s. The pulp and paper industry is the largest industrial wood consumer. Over 95% of paper in the United States is made from wood. Each year, the industry consumes more than 12,000 square miles of forest and less than one percent of total pulp produced is manufactured from non-wood paper alternatives (Treecycle, 2005).

Kenaf industry is new to Tennessee's marketplace. Despite the diverse uses – from papermaking to high-end industrial uses, kenaf industry development remains to be seen because of the "chicken or egg dilemma". Farmers will not plant kenaf unless profitable market is available while investors are reluctant to put up expensive paper processing facility without the assurance of a year-round supply of raw kenaf. As such, several important economic issues confronting kenaf commercialization must be addressed for the industry to grow. Despite the limited resources, kenaf paper is now sold in limited quantity to several commercial retailers and used by major corporations, printing and graphics firms and publishers (Cold Mountain, Cold Rivers, 2005).

2. Market Channels and Marketing Arrangements

Marketing of crops is one of the most important undertakings in any farming endeavor because this directly affects profitability. Being new to the industry, it is appropriate to examine other crops' market channels and arrangements that may be applicable to kenaf. These crops have similarity to kenaf because they are also light and bulky to transport. Increased in transportation costs significantly affect the competitiveness position of kenaf.

Tomatoes have varieties that are bred specifically to serve the requirements of either the fresh or the processing markets (USDA-ERS, 2005). Most tomatoes grown for processing under contract arrangement are typically machine-harvested while fresh ones are hand-picked and are sold to open market at higher price due to larger production costs and greater market uncertainty. Grower-owned cooperatives or marketing associations are able to assemble truckloads of produce required by large customers, which would not be possible for small growers acting individually (USDA-ERS, 2005). Organized cooperatives may also provide technical assistance, equipment and supplies to growers. Terminal markets are also ideal for tomatoes where several wholesalers, distributors, and brokers are clustered together.

Hay is a relatively bulky, low value commodity. Maximum value must be obtained from the hay through the production of high quality product at cost low enough to offset the high cost of moving the product to the end user (Tremblay, 2000). The hay market can be either domestic or overseas, with end use and associated quality requirements being the main defining elements of each market (Crespi and Sexton, 2004). Subsequently, most overseas markets for long hay are accessed through cooperation with a processing or marketing company. Many hay producers prefer a brokers' market than an end user market. Brokers have the necessary skills to sell their hay and often provide transportation costs, and work with suppliers on a long term basis if quality can be assured. Consequently, brokers demand their suppliers' loyalty, consistency in quality and supply, stable price and appropriate packaging (Crespi and Sexton, 2004).

On the other hand, evaluating the prevalent marketing practices of kenaf potential competitors in both the production and demand side offers a great challenge to kenaf. Tennessee is one of the major cotton producers in the United States with a production of 1,122 thousand bales (USDA, 2005). Cotton was typically sold and marketed through contract growing, cooperative marketing, brokers' markets, spot markets while some sold directly to mills. On the other hand, pulpwood products were often marketed using a combination of tapered integration approach and contract growing built on long term relationship (Stier et al., 1986). This approach assures processors of stable feedstock.

3. Market Structure

The introduction of kenaf in Tennessee would directly influence competition in a given market. Thus, it is appropriate to examine the different market structures that possibly exist on the production and demand sides of kenaf. On the production, kenaf would likely be having tough competition with cotton while pulpwood competition on the demand side. Marketing contract agreement is an increasing practice in the cotton industry particularly in large scale production. Nevertheless, cotton markets are still generally considered perfectly competitive markets where many sellers and buyers exist. In most cases, farmers are price takers.

On the other hand, kenaf may have a different market structure. Kenaf may be the only feedstock for the pulp market in a specific location, its market structure may resemble to that of a small monopoly and monopsony mainly because there will likely be no open market for the product. A monopoly is defined as a single supplier of goods and its faces the entire market demand curve for its product and can choose to operate at any point on that demand curve (Nicholson, 2005). As such, it can choose whatever price-quantity combination on the demand curve for its product and therefore, has no supply curve. A monopolist faces downward-sloping demand, implying that as it raises price, it sells fewer units. Marketing through cooperatives may be a feasible approach for kenaf producers to market kenaf. Cooperatives have the capability to collect the required volume of kenaf needed by the processor. This wouldn't be possible for an individual farmer. It may also provide technical assistance and other needed equipment to the farmers to assure uniform quality of produce. Nonetheless, the cooperative that handles the collection and marketing of raw kenaf would be considered a monopolist because as a cooperative it becomes the sole negotiator and supplier of raw kenaf materials to the processing facility. Unlike the model where prices are set at the pleasure of the monopolist, prices of kenaf raw materials will be based on a set of negotiated contract agreements. Contract agreements serve to protect both the buyer and the cooperative from production risk, market uncertainty and price unpredictability. Taylor (1984) reported that in the south, contract growing seemed to be the way to finance production. Contract increases production scale and efficiency and assures a ready market for a product. Kenaf may also have a monopsony type of market structure. Kenaf processor would then become the only buyer of feedstock for pulp. In theory, a firm is a monopsonist if it faces almost no competition in one of its input markets and has the ability to increase (decrease) its input prices. Nevertheless, the monopsonist power is limited due to the marketing contract arrangements set at a predetermined market price and volume.

Second, on the demand side, kenaf would be a direct competitor of pulpwood products. On a wider market scope, potential kenaf processor would encounter existing oligopolistic and oligopsonistic market structures because there are only a few pulp processors and sellers in Tennessee, respectively. At present, there are three existing pulp processors located in West Tennessee and Southeast of Tennessee producing around 283 thousand of short tons (CPBIS, 2006). An oligopoly is a type of market structure having few sellers that make the product, barriers to entry is high, and changes in marketing strategies like price reduction significantly affect other interdependent firms. However, on a narrow scope of the market specifically where kenaf could feasibly be grown, it would likely be competing directly with a small scale pulpwood processing monopolist producing an estimated output of 50 thousand short tons of pulp annually. Third, another oligopoly market would exist if we further assume that existing pulpwood processors convert their facilities to accommodate both pulpwood and kenaf pulp. If this happens, competition for the kenaf feedstock would increase and negatively impact the supply source of the kenaf pulp processing facility. In Tennessee, the current pulp processing facilities that might be converted to using kenaf exist in the Chattanooga area and perhaps in Memphis[4]. However, despite this competition, future trends of kenaf seemed to be promising as current developments of kenaf in the U.S. paper industry include significant research and product development (Rymsza, 1998).

4. Strategic Marketing Management (SMM) Model

Figure 1 illustrates the overall Strategic Marketing Management model. As a tool, SMM serves a road map for overall direction and strategies focused on customers' satisfaction and potential competitors. Analysis methods incorporated in SMM included SWOT and Porter's five forces competitive models. A description of these methods and their use in this analysis follows.

4.1 The SWOT Analysis

SWOT analysis is a subjective assessment of information. Nonetheless, as a tool, it provides valuable source information in decision-making related to competitiveness of a business firm in a given market. SWOT also offers a complete picture of how well the firm is expected to operate in a competitive business environment by providing a road

---

[4] Note: the plant in Memphis currently uses recycled newspaper to produce pulp and not pulpwood. Therefore its capability of being modified is unsure at the present time.

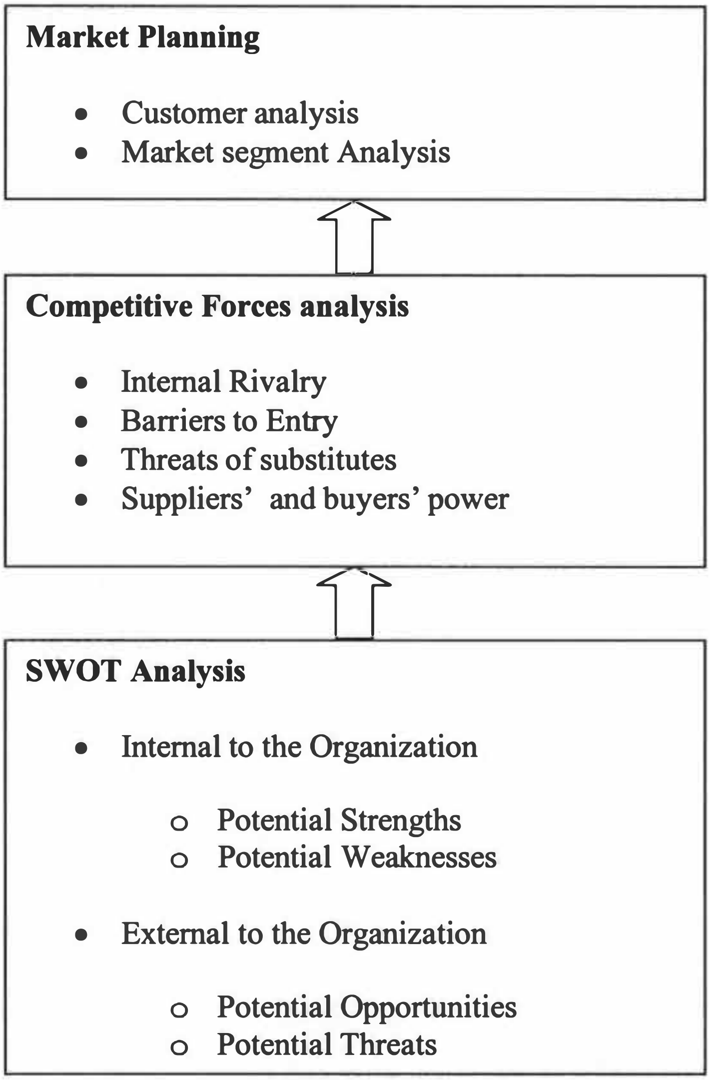

Figure 1. Strategic Marketing Management Model

Source: Strategic Marketing Management: Building Foundation for your Future, University of Florida Extension map of information of new opportunities that the firm could capture in the future accomplishment and assist firm prepare during market uncertainty. This analysis is commonly used by managers in evaluating firm's competitive advantage and design plans to help business absorb impact due to changes in the market forces. It does help management choose from array of decision alternatives critical to the business and the industry. Nevertheless, SWOT analysis should be anchored on areas that the firm's strengths matches the opportunities and analyzes areas where weaknesses make the firm vulnerable to threats (Wysocki and Wirth, 2001). Figure 2 illustrates the strengths, weaknesses, opportunities and threats (SWOT) of kenaf paper commercialization. SWOT is divided into two broad categories, namely: Internal factors (Strengths and weaknesses) and external factors (opportunities and threats).

4.1.1 Internal to the Organization

Controllable factors (strengths and weakness) are internal to the organization. These could be modified and restructured based on needs to help identify effective strategies to cope with industry changes and market demand.

4.1.1.1 Potential Strengths

Analysis on potential strengths gives information on how well the potential investor of kenaf processing plant is likely to perform relative to its rivals in paper industry. Among the potential strengths were described below:

<u>Location of the processing plant.</u> The location of processing plant is a crucial factor to successful commercialization because kenaf is lightweight, low density and bulky to transport at a distance. The nearer the plant to the production area, the more

SWOT ANALYSIS

Internal to the Organization

Potential Strengths	Potential Weakness
Location of processing plant	Financial constraints
Product innovation	Customers are unaware of the product
New machineries and technology	Lack of sufficient market information
Established information technology and infrastructure	Lack of reliable distribution channels
Competitive learning curve	Newly hired personnel lack skills in production and marketing
Good management capability	Problems on economies of scale of operation
Good reputation and public image	

External to the Organization

Potential Opportunities	Potential Threats
R and D related to kenaf production And processing	"Chicken or egg" dilemma
Possible entry to the market	Seasonal harvest
Product differentiation	Difficult to consolidate small farms to undertake kenaf production
Environmentally friendly technology	Vulnerability to economic slowdown
Diverse crop uses	Possibility of intense competition
Tapered integration strategy can be applied	Possible entry of new entrants to the industry
Ideal agro-climatic conditions	Conversion of existing pulpwood facility
Raw materials are renewable annually	
Compatibility to existing farming practices and equipment	

Figure 2. Kenaf commercialization potential strengths, weaknesses, opportunities and threats

efficient would the handling of transportation and marketing of products be which would increase firm's comparative advantage over that of their rivals. Several studies conducted on economic feasibility consistently suggested that processing plant location should be within the 50-mile radius in the production area to reduce transportation and marketing costs and increase kenaf competitiveness.

Kenaf is economically feasible to produce in some regions of Tennessee. This may offer substantial advantage to potential investor in Tennessee because it can select and identify viable production areas to put up the processing plant.

Product Innovation. Kenaf paper is designed to meet not only the growing demand in the export market but also caters to domestic market. Kenaf is basically an innovative paper because it is different from other types of papers sold in the market yet its quality is comparable to those paper made of virgin tree. The underlying technology used in the production of paper significantly minimizes environmental pollution. With adequate volume of raw materials, kenaf paper is expected to be at par with other competitors in the market in terms of price and quality. In addition, kenaf also offers an excellent fiber alternative to blend recycled paper.

New machineries and technology. Potential investor on kenaf processing should be banking on this strength over that of their rivals on the new design, advanced and efficient technology and equipment because these considerably reduce expenditures while increasing output. Technology in kenaf processing requires minimal energy and produces less polluting effluents critical to environment. Thus, reduces cost of operation such as establishment of complicated and expensive water treatment facilities because waste water can even be used to irrigate the fields.

Established information technology and infrastructure. Information technology and infrastructure are becoming indispensable component in competitive business environment. Potential kenaf processor is assumed to have suitable accounting, planning, implementation, and control systems readily accessible for strategic decision making. Advancement in information technology and infrastructure produce efficient output and reduce time spent not in operation. This increases efficiency and profitability.

Competitive learning curve. Experience in production increases efficiency has something to do with early-mover advantage. Besanko (2004) defined learning economies as the reduction in unit costs due to accumulating experience over time. Learning economies may be substantial even when the economies of scale are minimal. Initially, it is assumed that potential investor has been in business operations in other states for a number of years now. Given this assumption, the processor's experience relative to kenaf paper processing is significantly viable. Sufficient experience in kenaf processing and new technologies significantly drives the firm's efficiency and competitiveness in the market. With a strong learning curve, it causes unit cost to decline as production volume builds in due time, a high volume manufacturer can have the competitive advantage of being low-cost producer (Thompson and Strickland, 1992).

Good management capability. This expansion plan of kenaf processing plant is a tangible indication of a well-managed company. This leads to the idea that the company had a track record of well-defined core of management competencies and skills essential to carrying out various aspects of production and marketing functions for a successful business venture. Investing in areas of Total Quality Management program and relevant management trainings may help strengthen competitiveness position in the industry.

Good management should always find out how things work in the industry and introduce appropriate changes as needed. It always sees to it that support key functions in the organization are working together to achieve the desired goals set by the firm.

Good reputation and public image. This is an asset that the firm must cultivate and maintain. Despite being new to Tennessee marketplace, its operations in other areas proved that the company has set certain management practices and product standards. Regular participation to provide information through lectures during kenaf symposia and conferences as well as continue to provide good quality products to customers are important strategies to maintain firm's reputations to the consuming public.

4.1.1.2 Potential Weaknesses

One of the limiting factors in developing new markets for kenaf is putting the business idea to work. This includes how well the company is expected to identify marketing strategies suitable for commercialization of kenaf in the domestic market such as consistent quality and volume of supply at competitive price, and how effective the company addresses essential barriers to market development to mitigate firm's weaknesses.

Financial constraints. Construction of new processing facility requires huge capital investment: Sunk cost and fixed asset acquisitions like new building, machineries and technologies to market promotion. Early years of operation is critical as cost of operation may be higher due to large overhead and fixed costs. Potential investor may be constrained in establishing a small-scale pulp and mill because of inadequate financing.

This may significantly limit cash flow. Sourcing out capital to finance necessary expenditures in production and marketing must be thoroughly sought for.

Customers are not aware of the product. Though kenaf paper has been sold in some parts of the United States and exported to other countries like China, being new to Tennessee's market, key hindrance to commercialization of kenaf is that prospective customers in the domestic market are not aware of the product. In most cases, customers have to stick to products where they are familiar of and would likely associate kenaf paper with other existing paper products in the market based on price and quality. Marketing strategy such as establishing brand and quality through advertising and promotion is a way to start. This could be done by carrying out effective information dissemination and creating strategic distribution channels in the identified markets to reach a relatively large number of customers - the wider the coverage of product exposure in the targeted markets, the greater the possibility of market penetration. However, this needs considerable market information dissemination to persuade broad-range of customers and may burden the firm financially because of the high cost involve.

Lack of sufficient market information. Kenaf processor, the new player in the industry is expected to face uncertainty in the operations due to lack of market information. As mentioned, the federal government does not gather kenaf statistics. Hence, historical price is impossible to collect. Comparing the delivered cost of kenaf and pulpwood on per ton basis is difficult at this time because the plant location is unknown and therefore, transportation costs involved can not be determined.

Lack of reliable product distribution channels. Another potential problem related to market information is the limited product distribution channels. Existing wholesalers and retailers operating in the current markets are well-accustomed to distributing the existing paper products. Persuading them to distribute and sell new products is essential to gain entry to the market.

Newly hired personnel lack skills in production and marketing. Most often, these newly hired personnel lack the essential experience and skills about the business. Competition is tough. Hence, skills and competencies of the people must be honed to be competitive in the industry. Investing on human resource through appropriate training advances the workforce in accomplishing targeted goals.

Problem on economies of scale of production. In most cases, at the onset of operation, economies of scale of production limits considerably market entry. Start-up kenaf processing plant is usually operating under a small-scale production system. Rymsza (1998) cited that kenaf is still specialty fiber and specialty products and are produce in small volume. This indicates that prices of kenaf are higher compared to other paper products sold in the market. To be competitive, kenaf should gain first significant market share to increase profitability. However, the lack of markets and reliable distribution channels may potentially result to diseconomies of scale because full production capacity may not be possible and thus, possibly not able to meet the required volume of product in the market. Nevertheless, if it gains market acceptance, in the long run, it can increase in market share and ultimately reduce costs and product inventory.

4.1.2 External to the Organization

External factors are beyond the control of the organization. These factors may either be opportunities or threats to the business. Ideal business to operate should have greater number of opportunities rather than threats. Effective strategic management and planning helps the business minimize the impact of changes in the market forces.

4.1.2.1 Potential Opportunities

Initial step to analyzing marketing opportunities is to identify potential long-run opportunities taking into account its market experience and competencies indispensable in designing the marketing strategy for the firm.

Research and Development related to kenaf production and processing. At present, there are a number of available of researches that have been conducted related to kenaf processing including pulp and papermaking. This information helps prospective investors improve their processing capability. Besides, valuable information generated from these researches help enlighten targeted customers regarding the new product.

Scott et al. (2001) conducted a biopulping[5] processing study on woody and non-woody plants in the recent past. Results of the study indicated that the process appears to be economically feasible based on the electrical energy savings and the strength improvements. The study cited that with biopulping process on non-woody lignocellulosic kenaf showed more promising results than wood. This breakthrough is an opportunity for the prospective investor to further improve their competitive advantage in the industry.

---

[5] Biopulping is defined as the treatment of wood or other lignocellulosic with a natural lignin-degrading fungus prior to pulping.

Possible entry to the market. Benchmarking could be one of the most suitable approaches to capture demands of the market. Information generated will be valuable to the management in assessing business practices and opportunities in the industry. Previous researches revealed that kenaf potential to paper industry is remarkable, and the shortage of supply of paper makes kenaf an ideal alternative source of product to potentially gain entrance to the market in the local market. For instance, in the United States, paper production is 81,792,000 MT, of which 15,941,000 MT are imported (Mongabay, 2006). About 8,225,000 MT are exported. An estimated 89,608,000 MT are consumed annually in the local market. This offers a huge opportunity for kenaf to fill in the vacuum.

Product differentiation. Kenaf offers a unique quality of product to emerge in the market because it is made out of kenaf fiber. Its quality is comparable to paper made out of wood pulp. What makes this product different from other papers is it does not only provide good quality paper but also help maintain the balance in the environment. This is a significant advantage of kenaf has to offer to broad range of market segments suited to their preferences.

Environmentally friendly technology. This is one of the advantages that potential investor should be banking on - what makes kenaf a good alternative paper products and by-products in the market? While it provides alternative good quality papers to various customers, it also provides pollution-free environment because it uses hydrogen peroxide in bleaching process. Likewise, this provides positive externalities to the consuming public.

Diverse crop uses. Research and development efforts consistently recognized kenaf as a promising alternative fibers source to replace pulpwood fibers in papermaking. Kenaf paper has been tested to work comparably and efficiently just like the paper made from tree. It can be used in fast speed printers efficiently, and resistant to yellowing. It is also an excellent material for paper recycling. Other than pulp and papermaking, kenaf could also be used in various high-end agro-industrial products.

Tapered integration strategy can be applied. Contract growing between farmer-cooperative and processor has been cited as one of the most feasible arrangement to grow and market kenaf because it reduces market uncertainties. If contracted volume of supply may not be sufficient, the processor has the option to adopt tapered integration[6] strategy to boost additional year-round supply of raw materials. However, this strategy divests investment funds.

Ideal agro-climatic conditions. At the farm level, another opportunity for kenaf, it could possibly be grown profitably here in some regions of Tennessee because of suitable weather condition such as high humidity, good soils and long growing periods. There are also different varieties of kenaf available that could be planted suited to a particular agro-climatic condition to optimize production. When proven this emerging industry to be attractive, it will attract more farmers to engage on kenaf production, thus, increases year-round supply of raw materials.

Raw materials are renewable annually. Unlike pulp and paper derived from trees, supply of raw materials can be produced and renewed every year. Processing plant does

---

[6] Tapered integration is a mixture of vertical and market exchange in which a manufacturer produces some quantity of an input itself and purchases the remaining portion from independent firms (Besanko et al., 2004)

not have to wait for several years for the raw materials and are grown in proximity to the processing plant. Any adjustment in terms of quantity and quality demanded could be negotiated in an annual basis.

Compatibility with existing farming practices and equipment. Kenaf could be grown alone or in rotation with traditional crops making it more flexible for contracted farmers to manage farm production efficiently. Farmers interested in the production of kenaf will not find a hard time adjusting to this crop because the technology used is compatible with existing farming systems. It requires minimal cost of production due to minimal fertilizers and pesticides under no-till farming practices. Meanwhile, existing machineries used on sugarcane can be used to harvest kenaf. Cotton equipment could also be used to bale harvested kenaf.

4.1.2.2 Potential Threats

Threats posed unfavorable development to the business. Without potential defensive strategy, it could significantly erode firm's profits and competitiveness in the market.

"Chicken or egg" dilemma. This situation remained to be the major threat to kenaf commercialization. At present, there is no open market for kenaf. Farmers are reluctant to go on production unless market is certain while processor does not commit to invest unless production is guaranteed. Effective agricultural policy formulation and consolidation of efforts among stakeholders in the industry may help facilitate the establishment of market.

Seasonal harvest. Seasonal production does not guarantee processors of year-round supply of quality raw materials. Timing of the marketing decision is very important in marketing agricultural products to minimize this problem. In addition, annual crops are susceptible to weather conditions, pests and diseases may further contribute to low fiber supply. This may potentially reduce volume of raw materials. Subsequently, the once a year harvest of the crop may pose additional problem to the firm because this requires machineries and huge storage facility to store kenaf for a year-round supply. Hewitt (1997) pointed out that huge inventory of machinery required to complete the harvest and may probably cause overinvestment in agriculture and social cost to society.

Difficulty to consolidate number of small farms to undertake kenaf production. It needs a considerable number of kenaf acreages for commercial production to take off. In most cases, farms are diversified and are small in acreages. However, this problem could be addressed by encouraging farmers to form a cooperative or tap an existing cooperative to undertake kenaf production because this issue does not only limit the number of potential kenaf acreage devoted to production but also affect economies of scale in production. Rymsza (1998) pointed out the existing mills are big which also requires large volume. Liu (2002) illustrated that for a pulp mill that produces 100,000 tons of pulp per year needs 40,000 acreage of kenaf.

Vulnerable to economic slowdown. This situation may not only erode the profits of the business due to reduction in demand and drive down profitability but may also trigger farmers to shift back to planting traditional crops. This condition greatly compromises the feasibility of kenaf.

Possibility of intense competition. Kenaf is economically feasible to produce in regions 1, 2, 4, 8, 11 and 13 (Avila, 2006). Region 2 would likely be the potential area where kenaf pulp processors directly compete with a cotton and pulpwood. On the production side, kenaf would likely be in direct competition with cotton where market channels are well established. Cotton industry stakeholders have been in business for many years hence, kenaf must thoroughly demonstrate a viable arrangement to persuade producers to shift production to kenaf. On the other hand, on demand side, kenaf would also compete with pulpwood. Currently, there are three existing pulp processors in Tennessee collectively producing 283 thousand short tons. However, in a narrow market where kenaf plant would be economically feasible to produce, say for instance in Shelby county, there is a possibility that kenaf would directly compete a single pulpwood processor. As a competitor in the industry, kenaf pulp is posed to encounter tremendous resistance and competition from this existing pulpwood company. This company has been in operation for long time and is adept in the utilization of pulpwood. Moreover, this firm may be a member of pulp and paper association that aggressively promotes wood paper products and has established markets and market channels that may significantly drive down kenaf competitiveness.

Possible entry of new entrants to the industry. If kenaf paper would be able to successfully penetrate the marketplace and gain considerable market share and increase market power, another threat would be for new entrants in the industry to come in. It will create generate competition and possibly bring down prices and profitability of industry players. For instance, kenaf competitors in premium and specialty papers include papers made out of cotton, hemp and wheat and rice straw paper and even pulpwood.

Conversion of existing pulpwood facility. Assuming that kenaf paper performs well in the targeted market and eventually enjoy increases market share, it is highly possible for the existing pulpwood mills convert existing facilities to accommodate kenaf, thus, making the competition in the industry more intense. Though modification of existing pulpwood mills is expensive because it requires additional facilities and equipment, Liu (2002) revealed that expenses related to modification of facilities and machineries can be recovered in shorter period.

4.2 Porter's Competitive Forces Analysis

Porter's competitive five forces framework is a tool for assuring systematic use of competitive principles to assess the current status of the industry (Besanko et al., 2004). This qualitative analytical tool provides convenient way to explore economic factors that affect profits of the industry. It helps draw distinction in a competitive environment (Figure 3).

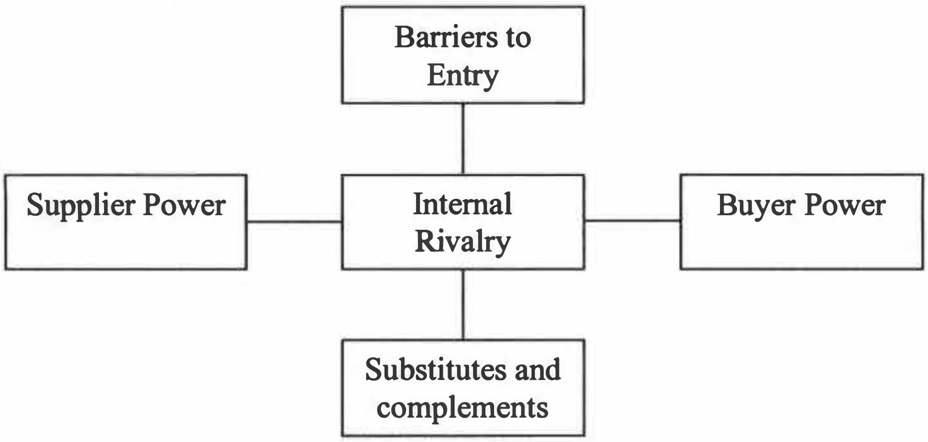

Figure 3. The Five-Forces Framework
Source: Besanko et al. (2004). Economics of Strategy

4.2.1 Rivalry Among Sellers

Considered as the most powerful of the five competitive forces (Thompson and Strickland, 1992), rivalry among sellers uses competitive weapons to compete for stronger market position and win competitive edge to achieve market success in a dynamic market place. This involves manipulation of market share to the disadvantage of other players within the market.

As a new entrant to the industry, kenaf is expected to face competition from the pulpwood processors. Its presence threatened the market share of incumbents and therefore, is expected to erode profits. On the demand side, the rivalry among sellers on a wider market scope, kenaf would likely be competing with pulpwood processors in Tennessee. However in potential area where kenaf is economically feasible to produce, it would possibly be facing a single processor. Subsequently, this pulpwood processor would need to sell more to cover its invested capital, and thus, will possibly lead to an intense rivalry. On the other hand, a rivalry among sellers may be considered less intense because current market demand for newsprint, writing papers and specialty papers is high, potentially spreading market share between players. This situation may provide an opportunity for kenaf to complement other existing paper products. In addition, high cost of entry minimizes rivalry because it discourages new players to invest in the industry. On the other hand, if kenaf gains entry to the market, this scenario would create a tougher competition because incumbents' market share may be reduced. Because entry and exit barriers are high, it will be too costly for an existing pulpwood processing facility to convert to kenaf paper processing and their expertise relies more on pulpwood processing not on kenaf. Consequently, these limitations leave no option for the incumbents but stay, invest on new technologies and compete in the market. This situation could generate intense rivalry in the industry.

Kenaf could be a price and non-price competitor in the industry. Price competition significantly reduces profits by driving price-cost margin while non-price competition erodes profits by driving up fixed cost (Besanko et al., 2004). As price competitor, kenaf offers more advantages than their competitors because raw materials can be sourced out locally and is renewable annually. Thus, it has the incentive to possibly bring down market prices to compete. As a non-price competitor, it provides customers high quality paper products and pollution-free environment. On the production side, competition between kenaf and cotton is potentially intense in terms of area devoted to production.

4.2.2 Barriers to Entry

Figure 4 illustrates market entry-exit barriers of the firm. Depending on market performance, kenaf entry to the industry could either have low, stable returns, low and risky returns, high and stable returns or high but risky returns. Assuming that kenaf business could have high and stable returns, it is possible to enjoy high economic performance and may invite competitors to enter the industry. This situation drives competitors of kenaf to put up new processing plants and/or convert existing pulpwood facility to accommodate kenaf.

Attractiveness of the market is dependent on the costs of entry and exit. On the production side, pulp industry has relatively high entry and exit barriers because of the huge investment cost involved. Kenaf entry in the market is constrained with significant budgetary requirements such as constructing the processing facility, access to a steady

Entry Barriers		Exit Barriers: Low	Exit Barriers: High
	Low	Low, stable Returns	Low, risky returns
	High	High, stable returns	High, risky returns

Figure 4. Barriers and Profitability of Entry to Paper Industry
Source: Kotler (2003). Marketing Management, 11th edition

feedstock supply, etc. It will also incur significant investment in promotion and marketing of products because customers not only unaware of the product but also of the lack of reliable product distributions channels. Aggressive marketing strategy should be directed towards persuading potential market channels to sell and distribute the product in the targeted market segments to enhance competitive advantage. It should also invest on the improvement of technological know-how, broaden market channels, create product awareness campaign among customers and establish strong reputation to be competitive in the market. On the production side, entry and exit barriers of both kenaf and cotton production are low unless farmers and/or cooperative are under marketing contract. This situation presents a threat to kenaf pulp industry as farmers have the potential to exit in the market.

4.2.3 Threat of Substitutes

Kenaf paper is itself a substitute to pulpwood and therefore, a threat to pulpwood industry. If it gains significant market share, its entry to the industry limits prices and is expected to reduce profits from the incumbents. However, for kenaf to gain acceptance among brand loyal customers, it must make considerable investment. As a substitute, it should be competitive in price, quality and possibly on volume. It should also prove that switching to kenaf offers more advantage than what the other products are recently offering in the market. Consequently, other than pulpwood, there are other specialty paper products that could potentially reduce kenaf competitiveness. These are paper made of cotton, hemp, sugarcane, wheat and rice straw.

4.2.4 Supplier and Buyer Power

Because kenaf has no open market, most feasible production and marketing arrangement would be through cooperative contract growing. This scenario portrays the cooperative as a monopolist, a single seller of raw materials. The cooperative has the responsibility to protect the interest of its members and to negotiate prices relative to the quantity required. Being the only supplier of the raw materials, supposedly, it has the power to increase (decrease) supply at a price above the marginal cost to obtain high profits. However, this power would be limited because of the marketing contract agreement and pressure from the cooperatives members.

On the other hand, equally important to supplier power is the buyer power. The no open market situation of kenaf renders the industry unattractive to farmers relying only to a single buyer. Producers are hesitant to produce kenaf because of the limited market option as price may be dictated by one buyer. Conversely, buyer power may also be limited due to marketing contract agreement. Therefore, to give both parties equal footing in business transactions, detailed contract agreement must be laid down even before production is started.

In theory, conditions where few sellers exist in a particular market, suppliers have more power. The same is true in situations where few buyers exist in a market that can purchase large quantities of feedstocks. This scenario provides more power to the buyer. On the demand side a kenaf pulp processing facility, as a start up company, may not have enough supplier power to leverage higher prices to prospective buyers in the paper market. However, the product characteristics of kenaf paper may increase its comparative advantage and market power.

5. Market Planning and Strategy

Basic to marketing process are the segmentation, market position strategies and customer analysis. These structures should balance firm's overall market strategies and competitiveness. Market segmentation is a group of customers having the same characteristics and each market is made up of various segments consisting of buyers with different needs and responses. Segmentation allows kenaf processors to focus on "customers' preference strategy", that is, its market decision making process should revolve around customer satisfaction. Customers are the driving force of the business, as a startup business in paper industry, it must work hard on essential marketing strategies to gain market entry and win potential customers. Offering to customers good quality at competitive prices put the firm on parity with their competitors. Establishing long term relationship with customers will considerably provide significant profits. Potential market segments may include the newspaper publishers, household consumers, schools and offices.

Market positioning, on the other hand, is an indispensable approach to effective marketing. To niche market, the firm converge its market position to challenge incumbents in the industry by offering differentiated products at affordable prices and pursuing a product development strategy to gain to potentially gain market share.

6. Marketing Problems

The SWOT analysis and Porter's five forces model have provided significant information with regard to the potential marketing problems of kenaf. Foremost, customers are mostly unaware of the kenaf products. This is a serious threat to a successful commercialization. Customers are the essence of business survival. Testing the product performance under a variety of potential uses might increase market awareness. Second, high barriers to entry such insufficient market information and reliable distribution channels and small scale production are also potential problems that may compel the firm to work from scratch to establish a viable market. This in turn requires substantial cost to set-up effective production and marketing strategies essential to market penetration. Consequently, the lack of essential marketing skills and experience among the newly hired personnel to efficiently access potential market segments may also result to low market share and profitability. Core marketing competencies must be harnessed to increase competitiveness in the market.

Lightweight and bulkiness of kenaf is another important problem to marketing because of the high transportation costs involved. Higher marketing costs reduce product competitiveness in the market. Moreover, the once a year harvest of kenaf may pose an important problem to the firm because huge volume of raw materials must be stored for processing. This situation may require large storage facility which may potentially result in overinvestment.

On the production side, the "chicken or egg" dilemma is the greatest obstruction to kenaf commercialization. Addressing this problem helped hasten the development of market kenaf in Tennessee. Seasonality of production is another important issue as this lead to erratic supply of kenaf. The difficulty of consolidating Small farmlands is also a potential marketing problem because kenaf requires contiguous track of acreages for cultivation to be economically feasible. Insufficient acreage devoted to kenaf would lead to further deficiency in the supply of raw materials. Moreover, the lack of knowledge in both the farming and management system of kenaf could be an effective barrier to commercialization.

Conclusion

Commercialization of kenaf in Tennessee is evaluated using the Strategic Marketing Management model. This model because has the ability to identify critical marketing factors that can either impede or accelerate new crop commercialization. Moreover, it helped decision makers create a road map business overall direction and strategies focused on customers satisfaction and potential competitors, and evaluate the performance of the firm and set priorities for changes in operation.

Despite the diverse uses of the crop: papermaking to high-end industrial use, kenaf market is still undeveloped. Apparently, the "chicken or egg" dilemma continued to be an important issue in market establishment. Producers will not grow unless assured of viable market and investors will not invest in expensive processing plant without a guaranteed year round supply. Higher production risk and market uncertainty further contributed to the problem. Cooperative contract growing is seemingly the only potential way to finance kenaf production and reduce marketing risk by assuring producers and buyer of stable price and continuous supply.

On the production side, kenaf would likely have a direct competition with cotton as well as other agronomic crops. In addition, kenaf faces competition with pulpwood on the demand side. Cotton marketing arrangements could be contract growing, selling directly to brokers and mills and cooperative marketing while pulpwood were mostly grown and marketed through contract agreements and tapered integration.

Currently, kenaf has no open market. This characteristic may lead to the formation of a monopoly-monopsony type of market structure with contract growing as the most feasible alternative to market raw materials. Though a monopoly is typically applicable to durable goods, the closed market situation suggests it may occur in the kenaf market as well.

Potential strengths of the firm include potentially located within the production area, product innovation, good management and reputation and new processing technologies. However, the lack of market information and reliable market channels, information and customers not aware of the product are also some of the potential weaknesses that the firm has. On the production side, a kenaf processor would serve as a direct market while on the demand side market channels for kenaf paper may include major newspaper publishers, advertising firms, wholesalers, foreign trade, and retailers. Pollution-free processing technology, compatibility to existing farming practices, raw materials are annually renewable are some of the potential opportunities considered while potential threats involved the financial constraints, "chicken or egg" problem, seasonality of raw materials, and intense competition from incumbents and expected new players. For commercialization of kenaf to succeed, there should focus on the maximizing its potential strengths, minimize its weakness and taking advantage of its potential opportunities while minimizing its weaknesses to improve market performance. Due to a relatively high transportation cost of kenaf, location of a processing plant will be critical to commercialization as well.

Outputs described in the Strategic Marketing Management model were broad in context and were intended to provide a comprehensive idea on the potential production and marketing advantages and disadvantages of kenaf. A detailed buisness plan or feasibility study should be conducted prior to establishment of a potential processing plant in Tennessee. Comparing cost of producing a ton pulpwood and that of kenaf pulp is beyond the scope of this study. However, it is suggested that this information should be incorporated in the detailed feasibility study.

References

Avila, G.S. "Economic Viability of Producing Kenaf in Tennessee." MS thesis, University of Tennessee, Knoxville, August 2006.

Besanko, D., D. Dranove, Shanley, M. and S. Schaefer. *Economics of Strategy.* 3rd Ed. Singapore: John Wiley & Sons (Asia) Ltd., 2004.

Burgess, C. "Kenaf". *Carolina Country.* July 2004, pp 22-23. Web accessed on March 23, 2005 at http://www.carolinacountry.com/storypages/ourstories/kenaf/kenaf.7.04.pdf

Center for Paper Business and Industry Studies (CPBIS). Web accessed on July 10, 2006 at http://www.cpbis.gatech.edu/millsonline/tennessee.php

Crespi, J.M. and Sexton, R.J. "Bidding for Cattle in the Texas Panhandle". Journal of Agricultural Economics 86(3), pp. 660-674. Web accessed on October 26, 2005 at Http://www.blackwell-synergy.com/doi/full/10.1111/j.0002-9092.2004.00609.x.

Cold Mountain, Cold Rivers. "Kenaf: An Ecological Alternative to Virgin Wood-Based Paper. 2005. Web accessed on October 26, 2005 at Http://www.wildrockies.org/cmcr/Pulp/Kenaf.html.

Engel, C. Taking Note on the Paper Industry. *Monthly Labor Review Online.* September 1997, Vol. 120, No. 9. Web accessed on June 16, 2006 at http://www.bls.gov/opub/mlr/1997/ 09/ art5exc.htm

Scott, G.M., M. Akhtar, G.C. Myers, M.S. Sykes, R.E. Swaney. "An Update on Biopulping Commercialization." In: Proceedings of the 3rd Ecopapertech Conference, June 4-8, 2001; Helsinki, Finland. Web accessed on June 12, 2006 at http://www.fpl.fs.fed.us/documnts/pdf2001/scott01a.pdf.

Hargrove, T. "Kenaf: A Cousin of Cotton – Could Catalyze Paper, Oil Pollution Industries." University of Texas A&M Agricultural Research and Extension Center, TX, September 1997. Web accessed on August 15, 2005 at http://www.agcomintl.com/kenaf.htm

Hewitt, W. "Economic Feasibility of Switchgrass Production and Utilization in Tennessee." PhD Dissertation, University of Tennessee, Knoxville, August 1997.

Kotler. P. *Marketing Management.* 11th Ed. Upper Saddle River, New Jersey: Pearson Education, Inc., 2003.

LeMahieu, P.J., E.S. Oplinger and D.H. Putnam. "Kenaf". Alternative Field Crops Manual. Department of Agronomy, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin – Madison. 1991. Web accessed on August 2, 2005 at http://corn.agronomy.wisc.edu/alternativeCrops/ kenaf.htm.

Liu, A. "Making Pulp and Paper from Kenaf." 2002. Web accessed on March 23, 2005 at http://www.Chinaconsultinginc.com/paperpulp.html

Mongabay.com. 2006. Web accessed on January 5, 2006 at www.rainforests.mongabay.com/deforestation/ production/United_ States.html

Nelson, P.A. and Cook, A.L. "Cultivating Kenaf for Fiber in Tennessee." 1998 (Abstr). Web accessed on August 2, 2005 at http://www.aaic.org/98progrm3.htm.

Nicholson, W. *Microeconomic Theory: Basic Principles and Extensions*. 9th Ed. Ohio: South-Western, part of the Thomson Corporation. South-Western, Thomson, Mason, 2005.

O'Connell, P.F. *Commercializing Promising Technologies*. In: J. Janick and J.E. Simon (eds.), Advances in new crops. Timber Press, Portland, OR. 1990, pp. 25-28.Web accessed August 8, 2005 at http://www.hort.purdue.edu/newcrop/proceedings1990/ V1-025.html

Omahen, S. "New Product Offers Farmers Market for Kenaf." Georgia Agricultural Experiment Station, College of Agricultural and Environmental Sciences, University of Georgia. December 19, 2001. Web accessed on August 5, 2005 at http://www.uga.edu/discover/educators/readings/ read86.pdf.

Roseberg, R.J. *Underexploited Temperate Industrial and Fiber Crops*. p. 60-84. In: J. Janick (ed.), Progress in new crops. Alexandria, VA: ASHS Press, 1996. Web accessed on August 17, 2005 at http://www.hort.purdue.edu/newcrop/ proceedings1996/V3-060.html#kenaf

ReThink Paper. Kenaf –the clean paper crop. An alternative to virgin wood-based paper. 2006. Web accessed on April 10, 2006 at www.rethinkpaper.org/content/kenaf.cfm

Rymsza, T.A. "Creating High Value Markets for Kenaf Paper: A Commercial Experience." Paper presented at the First Annual Conference of the American Kenaf Association, San Antonio, TX, 28 February 1998. Web accessed on March 24, 2005 at http://www.visionpaper.com/PDF_speeches_papers/982aks.pdf

Rymsza, T.A. "Developing a Kenaf Pulp Mill Project." Paper presented at the American Kenaf Society Conference, Atlanta, GA, November 2001. Web accessed on November 28, 2005 at http://www.visionpaper.com/speeches_papers/AKSPulp_mil_overview.html

Rymsza, T.A. "Utilizing Kenaf for High Value Paper Applications in the U.S.A.: A Commercial Experience." Paper presented at the High Performance Paper Society, Takamatsu City, Japan, October 29, 1998. Web accessed on July 11, 2006 at http://www.visionpaper.com/PDF_speeches_papers/hppsjapan.pdf

Sullivan, P. "Kenaf Production". Appropriate Technology Transfer for Rural Areas (ATTRA) – National Sustainable Agriculture Information Service. June 2003. Web accessed on March 23, 2005 at http://www.attra/ncat.org.

Stier, C., W. Steele and J. Engelhard. "Pulpwood Procurement Practices in the Wisconsin-Upper Michigan Pulp and Paper Industry." *Northern Journal of Applied Forestry,* Volume 3, Number 1, 1 March 1986, pp. 10-14(5). Web accessed on July 10, 2006 at http://utk.library.ingentaconnect.com/content/saf/njaf/1986/00000003/00000001/art00005

Taylor, C.S. "A Systems Approach to Commercialization of Kenaf". Ph.D. Dissertation, University of Missouri-Columbia, May 1984.

Taylor, C.S. New Crop Factsheet. 1995. Website accessed on March 24, 2005 at http://www.hort.purdue.edu/newcrop/cropfactssheets/kenaf.html

The Carbohydrate Economy. "Kenaf: On the Fence." Volume 1, Issue No. 4. Fall 1998. Web accessed on January 24, 2005 at http://www.carbohydrateeconomy.org/library/admin/uploadedfiles/kenaf_On_the_Fence.html.

Thompson, A. and Strickland, A. *Strategic Management: Concepts and Cases.* 6th Ed. Homewood, IL: Richard D. Irwin, Inc. Von Hoffman Press., 1992.

Treecycle Recycled Paper. Web accessed on October 26, 2005 at Http://www.treecycle.com/pissues.html.

Tremblay, M. "Successful Hay Marketing." Saskatchewan Agriculture, Food and Rural Revitalization, Canada. 2000. Web accessed on October 26, 2005 at Http://www.agr.gov.sk.ca/docs/crops/forage_pasture/marketing/marketinghay2001.asp.

U.S. Department of Agriculture - Agricultural Research Service. Web accessed on August 2, 2005 at Http://ars.usda.gov/research/projects/projects.htm.

U.S. Department of Agriculture - Agricultural Research Service. Web accessed on August 5, 2005 at Http://www.ars.usda.gov/is/AR/archive/aug00/kenaf0800.htm.

U.S. Department of Agriculture - Agricultural Research Service. Web accessed on August 16, 2005 at Http://www.ars.usda.gov/is/graphics/photos/k7234-38.htm.

U.S. Department of Agriculture - Economic Research Service. Web accessed on October 26, 2005 at Http://www.ers.usda.gov/Briefing/Tomatoes/background.htm.

U.S. Department of Agriculture – National Agricultural Statistics Service. Web accessed on July 11, 2006 at http://www.nass.usda.gov:8080/QuickStats/PullData_US.jsp

Webber, C.L. III and Bishop, R.B. Jr. "Management Issues for the Production, Harvesting and Processing of Kenaf." USDA Agricultural Research Service, Oklahoma. 1998. Web accessed on August 17, 2005 at http://ieeexplore.ieee.org/iel4/5884/15675/ 00727814.pdf

Wiboonpoongse, A., S. Sriboonchitta, P. Gypmantasiri and K. Thong-ngam. "The Role of Contract Farming in Agricultural Transition in Thailand". Chang-Mai University. Thailand. 1998. Web accessed on August 16, 2005 at http://mccweb.agri.cmu.ac.th/agbus/data/research%20paper/ CONTR_JISSAAS98.pdf

Wikipedia.org Encyclopedia. Web accessed on November 11, 2005 at Http://en.wikipedia.org/wiki/Marketing.

Wysocki, A. and Wirth, F. Strategic Marketing Management: Building a Foundation for Your Future. Department of Food and Resource Economics, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainsvillle, FL, 2001.

Part IV. Summary and Limitations

Summary

The overall goal of this study was to assess the production feasibility and market potential of using kenaf as a feedstock for paper production in Tennessee. This thesis 1) evaluates the potential for growing this crop in Tennessee by comparing the cost and return and the break-even price for kenaf with soybean, corn, cotton and wheat, 2) identifies potential suitable production areas in the state of Tennessee, 3) analyzes marketing opportunities that could be developed for kenaf at a price that growers would be willing to produce it, 4) identifies potential kenaf marketing structure and marketing channels in the state of Tennessee, and 5) identifies potential marketing problems of kenaf.

The economic feasibility of kenaf pulp and papermaking in Tennessee was evaluated through simulation, budgeting and sensitivity analysis. Initially, Tennessee was divided to 14 regions based the different weather stations located across the State. Counties adjacent to each weather station comprised a particular region. Each soil in the region specified in the STATSGO were identified and adjusted to county level.

EPIC simulations were conducted for kenaf along with the dominant crops in 202 Tennessee soil types and 18 nitrogen levels (0-340 lbs in increments of 20 lbs). The Environmental Productivity Impact Calculator (EPIC) model was primarily used to simulate both kenaf and dominant crops yields. Based on these simulations, quadratic plus plateau response functions (QRP) were estimated. Profit-maximizing nitrogen fertilization rates and yields were identified for each soil using these quadratic response functions. QRP was used to estimate yield response to nitrogen application because it considers random variation in other limiting factors across space and time especially weather. Breakeven and two-sensitivity analyses were conducted.

The kenaf supply curve was mapped by plotting kenaf production for each kenaf price between $40/ton and $75/ton at $5/ton intervals. The supply curve depicts whether the forthcoming supply of kenaf was sufficient at a price low enough to be economically feasible. Finally, kenaf marketing was assessed using the Strategic Marketing Management (SMM) model. Descriptive analysis was used to analyze and describe potential market structure and marketing problems related to kenaf. SMM was used to evaluate kenaf commercialization in Tennessee because it has the ability to identify critical marketing factors that can either impede or accelerate new crop commercialization. It helped decision makers create a road map business direction and strategies focused on customers' satisfaction and potential competitors, and evaluate the performance of the firm and set priorities for changes in operation. Integral to this model are the Strength, Weakness, Opportunities and Threat (SWOT) analysis and Porter's Five Forces Competitive model. Potential market structures and marketing related problems were also assessed.

Net returns to land, labor and management of kenaf across regions differ because of the varying optimal nitrogen rates and yield in each soil type. Kenaf optimal nitrogen rates vary from 136.4 to 454.9 lbs/acre and yield obtained were from 4.5 to 12.5 tons per acre. On average, optimal nitrogen rates were as low as 204.8 pounds per acre and as high as 324.1 pounds per acre. Variation in yield and optimal nitrogen rates is influenced by soils types and weather conditions. Overall, kenaf is potentially suitable in regions 1, 2, 4, 8, and 11 because of the higher net returns it obtained compared to the dominant crop. Apparently, kenaf is a profit maximizing crop in regions where cotton and wheat.

Moreover, the economic feasibility analysis assumed that marketing costs were equal. If the cost of marketing kenaf is higher than the dominant, its competitiveness is reduced. Thus, affecting the expected net return to land and management, and would therefore, change the potential supply and acreages available for kenaf across regions. Further, calculated net returns assumed that market is established.

The economic feasibility of producing kenaf across regions was not sensitive to changes in nitrogen prices. As the nitrogen prices were increased (decreased) by 5%, 15% and 25% from the baseline, profitability decreased (increased) by only 3%, 7% and 13%, respectively. Increasing the price of nitrogen, yield of kenaf decreased but on s slower rate than the dominant crop. This leads to increased of kenaf potential acreages across regions relative to the dominant crop.

Breakeven prices vary across regions taking in reference to the net return to land, labor and management of dominant crop. The obtained breakeven price ranged from \$19.75 per ton in region 2 to \$74.69 per ton in region 9. On average, breakeven price ranged from \$42.00 per ton to \$69.21 per ton in region 2 and 9, respectively. Any price above the indicated breakeven in a particular each region, kenaf is economically feasible to produce because it provides producers positive net returns.

Less than 50% of the cropped lands in Tennessee are cultivated to dominant crops. This is typical farming practice among farmers in many counties in Tennessee to reduce production and marketing risks (Roberts et al., 2005). Nevertheless, production and marketing risks were not accounted in the analysis. Currently, kenaf market in

Tennessee is non-existent. As a new crop without an established market, growing is a risky venture compared to dominant crops due to uncertainties. Cooperative contract agreements greatly helped in reducing production risks and market uncertainties. It also assures producers and processor of predictable price and steady supply of raw materials.

Despite the diverse uses of the crop: pulp and papermaking to high-end industrial use, kenaf market is still undeveloped. Apparently, the "chicken or egg" dilemma continued to be an important issue in market establishment. Producers will not grow unless assured of viable market and investors will not invest in expensive processing plant without a guaranteed year round supply. Higher production risk due to uncertain production methods and market uncertainty further contributed to the problem.

On the production side, kenaf would likely have a direct competition with cotton as well as other agronomic crops. In addition, kenaf faces competition with pulpwood on the demand side. Cotton marketing arrangements could be contract growing, selling directly to brokers and mills and cooperative marketing while pulpwood were mostly grown and marketed through contract agreements and tapered integration.

Currently, kenaf has no open market. This characteristic may lead to the formation of a monopoly-monopsony type of market structure with contract growing as the most feasible alternative to market raw materials. Though a monopoly is typically applicable to durable goods, the closed market situation suggests it may occur in the kenaf market as well.

SWOT provided a complete picture of how well the firm is expected to operate in a competitive business environment. It also provides road map of information of new opportunities and help the management choose from array of decision alternatives critical to the business and the industry. Potential strengths of the firm include the following: location of processing facility, product innovation, good management and reputation, availability of R & D on production and processing, new machineries and technology as well as infrastructures. Potential weaknesses include financial constraints, lack of market information and reliable market channels, inexperience newly hired personnel and customers not aware of the product. Possible entry to the market, diverse crops uses, compatibility with existing farming practices, renewable annually and tapered integration are some of the potential opportunities identified for kenaf while potential threats include 'chicken or egg" dilemma, seasonality of production, difficulty of consolidating small farms, intense competition, possibility of new entrants in the market as well as the possible conversion of existing pulpwood facilities to accommodate and process kenaf.

For commercialization of kenaf to succeed, there should focus on the maximizing its potential strengths, minimize its weakness and take advantage of its potential opportunities while minimizing its weaknesses to improve market performance. Due to high transportation cost of kenaf location of processing plant is an essential to commercialization as well.

Porter's Competitive Five Forces model framework is a tool for assuring efficient use of competitive principles to assess the current status of the industry. This qualitative analytical tool provides convenient way to explore economic factors that affect profits of the industry. It includes internal rivalry, barriers to entry, threat of substitutes and suppliers' and buyers' power.

Limitations

EPIC simulations were used to mimic actual field situation by putting the data into the model. Results of the EPIC simulations showed that optimal nitrogen rates were higher in comparison with other studies previously conducted. This result of simulation model maybe overestimating the yield response to nitrogen application in higher undocumented level or may be due to the assumption that simulations assumed that other inputs are applied at sufficient level. As such, crop parameters may need further adjustment to reflect actual field scenario. Nevertheless, EPIC simulations provided a comparable data necessary to assess the impact of the introduction of new crop. In addition, this study did not reflect farmers' willingness to adopt kenaf under their current production and marketing systems. There is a need to further examine the overall production and marketing systems as there may be hidden costs not accounted that may significantly affect profitability.

On the other hand, outputs described in the Strategic Marketing Management model were broad in context and were intended to provide a comprehensive idea on the potential production and marketing advantages and disadvantages of kenaf. A detailed business plan or feasibility study should be conducted prior to establishment of a potential processing plant in Tennessee. Comparing cost of producing a ton pulpwood and that of kenaf pulp is beyond the scope of this study. However, it is suggested that this information should be incorporated in the detailed feasibility study.

Vita

Gerry Solano Avila was born in Cebu City, Philippines on January 10, 1970 to late Gregorio Avila and Felicula Avila. He has three sisters; Josephine, Jelen and Sylvia Avila-Heritage, married to Ernie Ralph Heritage. Gerry was married to former Julie Ann Cinco of Tacloban City, Philippines. They are blessed with two beautiful kids: Kurt Dominic and Julia Feliz. He finished his secondary education at Saint Augustine High School, San Agustin, Surigao del Sur, Philippines in April 1987. He received his Bachelor of Science in Agriculture from Leyte State University (LSU) formerly known as the Visayas State College of Agriculture in April 1991. After graduation, he worked as Research Assistant at the Farm and Resource Management Institute, LSU until 1998. In 1999, he joined the Department of Agriculture, Regional Field Unit VII, Cebu City, Philippines.

Having become convinced that pursuing graduate studies would be a good step towards professional development, he applied for the Fulbright-Philippine Agriculture Scholarship Program (PFASP) in 2003. The PFASP was awarded to him in 2004.

In August 2004, Gerry formally enrolled in the Master's degree program in the Agricultural Economics at the University of Tennessee, Knoxville. Gerry received his Master of Science degree with a major in Agricultural Economics in August 2006. Two years of graduate life at the University of Tennessee, Knoxville has enabled him to understand vast underlying issues and opportunities in the field of agricultural economics.