ENTREPRENEURSHIP IN SOUTHEASTERN NORTH CAROLINA: THE PARTNERSHIP THAT WORKS

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ABSTRACT

The Thomas Family Center for Entrepreneurship of the University of North Carolina at Pembroke (UNCP), with grant funding from the NCIIA, has improved the UNCP entrepreneurship program and collaborated with the UNCP Biotechnology Research and Training Center for the commercialization of an agricultural biotechnology product, Brave-Guard Beneficial Microworms. The coupling of these two efforts is a unique project for UNC Pembroke. Aside from the practical applications, this NCIIA-supported partnership provided real-life challenges that an entrepreneur might face when considering the launch of a new technology or enterprise. This report will provide an overview of the partnership between the Thomas Family and Biotechnology Research Centers. Successes are discussed, along with the problems and how real-life challenges were addressed to meet production and commercialization goals. It should be borne in mind that this project is not complete, but as with any other entrepreneurial endeavor, it has become an evolving practical enterprise spun from an academic theory. This project is a demonstration of "theory into practice."

Introduction: Coupling Entrepreneurship and Biotechnology at UNC Pembroke

The Thomas Family Center for Entrepreneurship (TFCE) of the University of North Carolina at Pembroke (UNCP), with grant assistance from the NCIIA, has been able to develop and improve a successful entrepreneurship program that is available to all students at the university. The entrepreneurship program now provides undergraduate students with a certificate, minor, or concentration, depending on student interests. The program has also established a MBA track in entrepreneurship with hands-on experience provided by the UNCP Biotechnology Research and Training Center in the development and commercialization of a biocontrol product. The NCIIA grant has enabled UNCP to advance current programs by funding the development of a course that focuses on how inventors can turn their inventions into businesses along with protecting their intellectual property. Additionally, grant funds from the NCIIA have supported regional E-Team entrepreneurship projects. With matching funds from other sources, the NCIIA grant money has also provided the Biotechnology Center with researcher salaries, equipment, materials, and prototyping for the newly developed biocontrol product. The new product, Brave-Guard Beneficial Microworms, eliminates crop insect pests in a natural and environmentally-friendly approach (Menefee, Holmes, and Inman III 2013).

The University of North Carolina at Pembroke

UNCP was initially established in 1887 as the Croatan Normal School, in response to a petition from the native Indian people of the area. The school opened with 15 students and one teacher

in the fall of 1887. The school was founded to train American Indian public school teachers. For many years, the instruction was at the elementary and secondary levels, with the first diploma awarded in 1905. The school moved to its present location in Pembroke, the center of the Indian community, in 1909.

Additional college classes were offered in 1931, and in 1939 a fourth year was added, with the first degrees conferred in 1940. In recognition of its new status, the North Carolina General Assembly changed the name of the school in 1941 to Pembroke State College for Indians. In 1953, the Board of Trustees approved the admission of white students up to 40 percent of the total enrollment and, following the Supreme Court's school desegregation decision, opened the college to all qualified applicants without regard to race in 1954. Growth of over 500 percent followed during the next eight years.

In 1972, the General Assembly established the 16-campus University of North Carolina (UNC), with Pembroke State University as one of the constituent institutions. The UNC Board of Governors approved the implementation of master's programs in professional education at Pembroke State University in 1978, as well as several new undergraduate programs. Since that time, additional baccalaureate programs have been added, including nursing. Master's level programs were implemented in business administration, public administration, and Service Agency Counseling. Pembroke State University celebrated its centennial in 1987. On July 1, 1996, Pembroke State University officially became The University of North Carolina at Pembroke. With a total enrollment of over 6,000, the university offers 45 bachelors and 17 masters' degrees.

Robeson County, North Carolina

The Thomas Family Center for Entrepreneurship (TFCE) and UNCP are located in Robeson County, the largest county in the state of North Carolina. Robeson County is a rural county located in the Coastal Plains of Southeastern NC. Based on the 2000 Census, its multiracial population of 134,567 is 38% Native American, 32% European American, 25% African American, and 5% Latino/Hispanic. The Asian population is less than 1%. Robeson County is home to the Lumbee Indians, the largest Native American tribe east of the Mississippi River.

Manufacturing in the United States has undergone intensive economic restructuring over the last three decades. This has had a profound effect on rural areas, especially in the Southeast where textile, apparel, and furniture manufacturing have been based. North Carolina, in particular, has been dependent on traditional manufacturing to support its rural counties' employment. The impact of General Agreement on Tariffs and Trade (GATT) and the North American Free Trade Agreement (NAFTA) has meant displacement for thousands of rural North Carolina workers. North Carolina job loss between 1994 and 2000 reached more than 100,000, with rural areas being the hardest hit. Robeson County has felt the brunt of economic restructuring. Between 1997 and 2000, Robeson County lost 41% of its manufacturing jobs. This predominantly rural county has seen significant increases in unemployment, bankruptcies, and substantial reductions in household income and business tax revenue. This has led to the county having the highest poverty rate (32.6%), crime rate, violent crime rate, and poorest health rate in the state of North Carolina. The need for more and better jobs through entrepreneurship efforts is apparent to combat the declining status of the county.

The Thomas Family Center for Entrepreneurship

The Thomas Family Center (TFCE) is making significant progress in its goal to revitalize the economy and generate business and employment opportunities

in the region. The center is affiliated with UNCP; it serves as a "Mecca" for all local area and regional residents who are seeking new entrepreneurship opportunities. The Center recognizes the correlation between entrepreneurship and economic development and is committed to education and research in this field.

Its goal is to stimulate entrepreneurial thinking amongst the UNCP student body, as well as to assist and support entrepreneurs and new ventures in the Southeastern North Carolina Region. As a result, TFCE's focus on education, research, planning, and community engagement is aptly captured in its mission statement: "Economic development and personal success are attained through entrepreneurs and innovators who thrive on imagination, creativity and passion." Established in 2006, the TFCE was enabled by a generous gift from The Thomas Family Foundation, founded by James and Sally Thomas. Mr. Thomas is from Pembroke, a Lumbee Indian, and a successful California entrepreneur. His concern for his home and people inspired the creation of the TFCE.

Through much of its history, rural North Carolina has been home to small-town merchants, talented craftspeople, and progressive farmers, all willing to take the risks necessary to build their businesses. Building on this entrepreneurial legacy, the Thomas Center strives to tap into this potential for small business development as a means of creating jobs and building wealth in rural communities. The center recognizes that rural communities have a strong history of entrepreneurial success and a powerful work ethic with which to build a base for future prosperity.

TFCE consultants reach out to and support the community by providing one-on-one consulting and evaluation services for local entrepreneurs while helping students develop entrepreneurial competencies and knowledge. The result extends entrepreneurship education outside the classroom by allowing students to work with local entrepreneurs on critical business challenges. Experiential learning is a great asset to entrepreneurship students. At the same time, local businesses benefit from the knowledge and advice provided.

NCIIA grants have enabled the university to engage students in the entrepreneurship efforts of the TFCE to aid the economic health of the county. These students work with local companies in the areas of marketing, finance, planning, accounting, product development, and human resources. The E-Team is currently working with the Biotechnology Center on the development, marketing, and commercialization of beneficial nematodes. The grants have also helped create a new course, open to all UNCP students, on invention and innovation. The new course covers areas of intellectual property, product testing, marketing, licensing, financing, and product improvement. It is believed that offering this course will encourage student invention, product development, and new jobs for the area.

Discussion of Agricultural Biological Control Products

Biological control (biocontrol) for agricultural systems is not a new idea. During the last century, more than 2,000 non-native (exotic) control agents have been used in at least 200 countries or islands with relatively few documented problems for flora, fauna, or the environment. Biocontrol of insect pests is gradually gaining momentum. Biocontrol is a now a component of integrated pest management (IPM) strategies, and is regarded as a "systems approach" to IPM.

Biocontrol is defined as the reduction of pest populations by natural enemies and typically involves an active human role. It includes the control of animals, weeds, and disease. Biological control minimizes the use of chemical pesticides. Biological control

platforms reduce but do not eradicate pests, and are typically used to suppress populations of pest organisms below levels that would have negative economic impacts. Natural enemies used in biocontrol measures include parasitoids, predators, microbes, and beneficial nematodes. There are many benefits to using biocontrol methods for agriculture, which include:

- Controlling insect or weed pest repression to manageable levels and reducing potential legal hazard of chemical use.
- Reducing acute and long-term impact of chemical pesticides on human, animals, non-target organisms, and the environment.
- No resistance buildup, making treatment increasingly less effective.
- No delay between application and harvesting.
- Protection of biodiversity and restoration of natural ecosystems.
- Chemical residue-free products from farms and natural systems.
- Potential to act as permanent reductions of pest organisms.
- Usually no phytotoxic effects on young plants (abortion of flowers).
- High benefit-to-cost ratio.
- The public is more accepting of biological control than chemical agents.

Barriers to Adoption of Biocontrol Approaches

Perhaps the biggest barrier to effective biocontrol is the necessity of educated management and planning. For optimum benefit, the user must understand the biology of the target pests and their natural enemies. In comparison to chemical methods, the risks associated with biocontrol to human/animal/plant health are very small. There have been a few reported cases of mild allergenic reactions in workers of production facilities; however, this risk can be mitigated by taking necessary containment actions. It is extremely unlikely that bites from introduced bio-control agents will occur; therefore they pose little threat to persons handling these agents. Plants may also be a secondary food for biological control organisms. Parasitoids and predators might sometimes supplement their diets with certain plant juices or pollen; however, they do not destroy entire plants. To date, there is no known example where introduced natural enemies of agricultural pests inflict significant damage to crops, native plants, or livestock.

Environmental risks and non-target effects have not been completely assessed. To fully understand the impact a biocontrol agent has on the environment, certain types of information must be known. Assessment science is not completely understood or applied in most cases. However, there is consensus that four major types of information are critical: A defined insect pest range must be determined in order for the agent to be successful on the target species. A sound knowledge of the biological agent and the insect host(s) must be available. A laboratory assessment can provide preliminary data on host/nematode interactions.

Abiotic and biotic factors should be determined with an understanding of the similarities between region of bioagent collection and the region of planned release. Abiotic factors include non-living chemical and physical environmental factors. It may also be vital to have knowledge about the development synchronization of the host and its natural enemies.

Knowledge of dispersal mechanisms for biocontrol agents can provide important data for dosages and timing of applications. The biological agent may be affected by dispersal methods being used. Other information regarding the agent size and behavioral traits, such as ranging and host foraging may also be needed. Potential direct or indirect effects on non-target organisms should be understood as completely as possible.

Mass Production of *Brave-Guard* Beneficial Microworms

Our work has involved discovery, development, and production technologies for the suspension culturing of three species (**Heterorhabditis bacteriophora, Steinernema carpocapsae**, and **Steinernema feltiae)** of beneficial nematodes in fermentation systems. Harvesting and packing protocols are also being adopted for shipping and marketing of **Brave-Guard** products. The major elements of the culturing are (1) strong, viable symbiotic bacterial cultures; (2) development of bacteria/nematode culture media; (3) discovery of culturing conditions to maintain inside the bioreactors (pH, dissolved oxygen, temperature, and culture agitation); and (4) harvesting and packaging (see Figure 1).

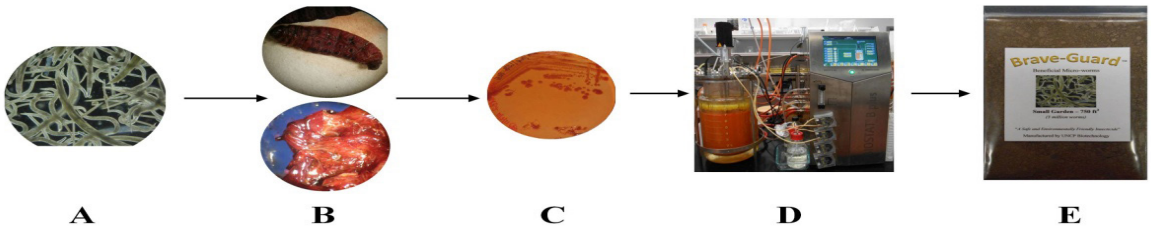

Figure 1. Mass production of Brave-Guard beneficial microworms. A) obtain microworms from a reliable source; B) infect a host insect with microworms; C) isolate bacterial symbiont from infected host; D) upscale bacterial symbiont in liquid media and after some time inoculate with obtained microworms; and E) harvest microworms and package final product (e.g., Brave-Guard)

The discovery and development work is based on extensive searches of scientific literature and four years of basic research in the laboratory. Equipment, materials, and researchers needed to carry out the work and develop protocols were generously funded through various sources: NCIIA, UNC Pembroke, federal, state, private foundations, and gifts from private companies and private individuals.

Research Scientists and Staff

The **Brave-Guard** project has led to significant academic results. Because it requires expertise in chemistry, biology, and fermentation, an array of skills are required. The laboratory has recruited fourteen PhD, MS, and BS level scientists, as well as numerous undergraduate students, to contribute to the laboratory work during the past four years. Seven of the scientists were international (India and France). Resulting research stemming from the **Brave-Guard** project has led to the publication of more than 20 research manuscripts and over 100 research talks and poster presentations (Inman III and Holmes 2012; Inman III, Singh, and Holmes 2012; Kooliyottil et al. 2013; Upadhyay et al. 2013).

Challenges in Production and Commercialization

Experience with production of **Brave-Guard** identified several commercialization challenges. These challenges, if not properly addressed, will delay or increase the cost of the final product. The challenges were identified throughout product development and are briefly explained below.

Consistency of Mass Production

Quality control is a critical factor in the success of any product. Quality control for manufacturing a biological or living organism is best assured through an adequate understanding of pertinent chemistry and biology and optimal operating parameters for manufacturing. Complete knowledge of best processes for mass production of complex organisms such as nematodes (microscopic animals) and bacterial symbionts are not generally known, which ultimately leads to potential quality problems. In the worst-case scenario, production failure can result. Production failures will impact cost, product availability, and product quality. Discovery and development is still in the early stages for Brave-Guard and production has suffered due to operational setbacks. Since the Brave-Guard product is not currently being marketed, availability and loss of sales is not yet problematic. Available packages of Brave-Guard are released to interested persons who are willing to test the product and provide relevant product feedback.

Production Capacity

A major factor that will affect the price of Brave-Guard is the quantity of microworms manufactured per production batch. Most of the cost for manufacturing (after permanent equipment capital) is attributed to labor. Our current production bioreactors range in working volumes from 2 to 30 liters. This is a 15-fold increase of theoretical product yield, but labor costs are practically unchanged. The increased cost of raw material is also not proportional to volume. Obviously, our production cost per unit decreases as bioreactor capacity increases. We plan to sell Brave-Guard microworms in individual packages containing 10 million microworms; however, upon customer request, quantities greater than 50 million can be sold with appropriate production lead times.

Production Costs

Production costs typically drive the final price charged to consumers. These costs can include, but are not limited to, labor and materials. Aside from one-time capital investments (i.e., equipment), labor is the most costly recurring expense. Labor costs can be reduced in different ways. The most effective avenue is the use of automated systems. These systems rely on signal feedback mechanisms generated during the production process. By responding to feedback signals, these systems reduce the amount of labor hours necessary for production.

Materials and supplies, mainly production media, are another production cost that can cause variation in product pricing. Materials needed for media formulation tend to become more expensive during scale-up to larger volumes. To avoid large media cost increases, optimization of media components will determine the minimal “ingredients” necessary to produce the product. Additionally, production media can be formulated to increase product yield and balance the cost of production media. In the marketplace, if production costs are reduced, the product price will also decrease. Products become more attractive to consumers when more affordable.

Pricing and Shipping Costs

The price of beneficial nematodes sold online varies; which does not include the cost for shipping. Nematodes are microscopic animals that should not be allowed to become hot (greater than room temperature or 75 degrees Fahrenheit). Brave-Guard is shipped in insulated envelopes with cooling materials during spring and summer months. To ensure product viability upon arrival, customers are requested to select shipping within two business days. Shipping adds significantly to the cost for the customer. For small packages of the product, the cost of shipping may exceed the cost of the product. Therefore, it is to the consumers’ advantage to purchase large Brave-Guard

orders. Unfortunately, at the present time there is no way to avoid high shipping charges, and this is clearly a marketing problem. In the future it may be possible to develop packing technologies that will allow lower-cost shipping.

Marketing

The promotion and marketing strategy of Brave-Guard is being led by the UNCP Thomas Family Center for Entrepreneurship. Funding from the NCIIA to one of the authors (Menefee) has been used to initiate marketing studies for the Brave-Guard product. A free website for Brave-Guard (https://sites.google.com/site/braveguardnematodes/) was created by UNCP undergraduate students as the first effort to promote and sell Brave-Guard. A YouTube™ video explaining some of the advantages of Brave-Guard beneficial microworms can be viewed on the website. There are plans to upgrade the Brave-Guard website. The project suggests that two customers exist: (1) Internet customers and (2) regional home, garden, and landscaping businesses. These businesses will present and sell Brave-Guard in their stores. It is anticipated that regional growers will also be interested in purchasing beneficial nematodes from UNCP directly.

Project Brave-Guard received university funds through the Thomas Center to hire an MBA graduate student to conduct a market study and develop a practical marketing strategy. The strategy recommends actions to promote the sales of Brave-Guard regionally:

- Locating, contacting, and determining product interest from local home, gardening, and landscaping businesses.
- Provide free Brave-Guard samples to interested businesses to test or distribute.
- Design attractive Brave-Guard advertisements (flyers, brochures, etc.) that contain details, instructions, and customer support information.
- Perform timely customer follow-ups to acquire results and customer reactions.

Regional Distribution for Field Testing

Brave-Guard product samples have been provided to several interested businesses and persons for efficacy testing. Brave-Guard has been field-tested for pecan stands, lawns, gardens, arthropod pests (ants, ticks, fleas), and greenhouses. Although these are limited studies, anecdotal reports were favorable. UNCP will continue to release Brave-Guard samples to interested users to initiate more field testing studies and spread product publicity.

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