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NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Efficacy and Marketability of Liquid Fish Fertilizer in Southern New Jersey

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The contributions of our numerous project cooperators were essential to the success of this project and are greatly appreciated (see APPENDIX I - PROJECT COOPERATORS).

The views expressed herein are those of the authors and do not necessarily reflect the views of the funding agencies or project cooperators.

Cooperating agencies are Rutgers, The State University of New Jersey, U.S. Department of Agriculture, U.S. Department of Commerce, NOAA Sea Grant, New Jersey Sea Grant College Program, New Jersey Sea Grant Marine Advisory Service, New Jersey Marine Sciences Consortium, and the Cape May County Board of Chosen Freeholders.

ABSTRACT

Fish hydrolysate can be produced from fish processing residuals by enzymatic digestion and be used as a fertilizer. Seafood processors can benefit from installing a fish hydrolysate plant through reduced waste disposal costs and by-product revenues. Such developments may also contribute to local employment and the long-term viability of fish processing plants.

The objectives of this project were to: 1) introduce the technology of producing fish hydrolysate to the fish processing industry in the port of Cape May, New Jersey, and 2) assist in developing markets for fertilizer produced.

A pilot hydrolysate plant was constructed at Axelsson and Johnson Fish Company. Product formulation was adapted from those developed for fish species in the Northeast fisheries. Testing by an independent laboratory demonstrated that the plant could consistently produce a fertilizer product with a balance of nutrients (2:4:2). This product was certified organic by the New Jersey branch of the Northeast Organic Farming Association and has been licensed by the New Jersey Department of Agriculture.

Several target markets were identified. Fish hydrolysate is a recognized product in commercial cranberry production and in organic farming and gardening. Controlled tests demonstrated efficacy of the fish hydrolysate comparable to synthetic fertilizer in cranberry production and comparable to other organic fertilizers in staked tomato production.

A model business development plan for fish hydrolysate determined that aggressive marketing, emphasizing ease of application and organic certification, is the key to business success. Competitive advantage is achieved by supplying local markets and minimizing distribution costs.

TECHNICAL REPORT

INTRODUCTION

Coastal Issue Addressed

Disposal of solid waste from the processing of seafood products in New Jersey, as throughout the coastal United States, has been recognized as a persistent problem for the industry (Fort Point Associates 1986). Increasingly stringent waste discharge regulations and rising disposal costs have raised operating costs. A study of 98 New Jersey food processors indicated that the cost and difficulty of compliance with solid waste discharge regulations are among the most significant impediments to expanded food processing in New Jersey, and are factors affecting the location decisions of Mid-Atlantic food processors (Lopez and Henderson 1989a&b and Henderson 1992).

Some seafood processing waste is disposed of in landfills, and landfill tipping fees have increased dramatically in recent years. For example, from 1987 to 1991, landfill tipping fees in two southern New Jersey counties of Cape May and Cumberland increased by 115.2% and 55.8%, respectively (Henderson and Strombom 1992). There is one public landfill in Cape May County, and it is scheduled to close by court order because it is located in the environmentally sensitive Pinelands area. This is expected to double Cape May tipping fees in the short-run and eliminate local landfill disposal as an option for seafood processors by 1996. The use of fish waste as swine feed is another traditional disposal method which is becoming unfeasible as the number of local swine farms decline.

State of Existing Knowledge

By-product development can contribute to the resolution of the seafood processing solid waste disposal problem. A variety of by-products have been suggested (Otwell 1981, Seafood Management Corporation 1986, Keller 1990, Goldhor and Regenstein 1991). One potential by-product is fish hydrolysate. The hydrolysate process uses protein-digesting enzymes to break down fish processing residuals into small particles that are in liquid suspension (Stuiber et al 1986, American Composite Technology 1986, Goldhor 1988).

The resulting hydrolysate contains nitrogen and other nutrients. Although evaluations of performance of fish hydrolysate for most crops have not been rigorously assessed, prior research on several crops provides cause for optimism that fish hydrolysate will be an effective slow release fertilizer. Research conducted at the University of Massachusetts Cranberry Experiment Station has shown that cranberry bogs in Massachusetts using fish hydrolysate produced comparable yields to conventional granular fertilizers (DeMoranville 1988, 1989, & 1990).

A 1986 study reported that the best northeast market for hydrolyzed fish by-products as a fertilizer is as a lawn, garden and turf fertilizer (Seafood Management Corporation 1986). Turf

studies by the University of California's Hopland Field Station showed that spray-dried, hydrolysed fish protein was superior to ammonium nitrate and ammonium sulfate, including even growth over longer time periods, and no burning of turfgrass even when grossly over-applied (Wyatt 1990). In addition, the fish fertilizer provided better greening at lower temperatures than did other organic fertilizers.

OBJECTIVES

The objectives of this project were to apply proven technology to assist a seafood processor located in the port of Cape May, New Jersey in producing liquid fish fertilizer from fish processing residuals and develop markets for this product in New Jersey production agriculture and home gardening. Development of a fish hydrolysate production facility in south Jersey offers an alternative disposal option for seafood processing waste. Furthermore, this project serves as a model for seafood processors in other regions of the country for turning their solid waste into a marketable by-product.

METHODS

Cranberry Field Trial

To determine the efficacy of fish hydrolysate as a fertilizer for commercial cranberry production, a controlled experiment was conducted during the 1993 growing season on a bed of *Early Blacks* located at the Rutgers Cranberry/ Blueberry Research Station in Chatsworth, New Jersey. Twelve 6'x 8' plots were established randomly across the bed. Three sample rings, 6" in diameter, were placed in each of the plots for a total of 36 rings. To provide control treatments, six of the plots were covered during the application of fish hydrolysate and fertilized separately with conventional fertilizer.

Nutrient requirements of the bog were determined based on soil and tissue analysis. Whole bed application of fish fertilizer was used. Fish hydrolysate, with nutrient composition of 2:4:2, was applied through the sprinkler system at a rate of 300 gallons per acre. Two application timings by crop growth stages were employed following previous research results in Massachusetts (DeMoranville 1988, 1989, & 1990). Granular fertilizer was applied to the covered areas at rates equivalent to those for the hydrolysate.

For each sample, the total number of uprights, fruiting uprights and vegetative uprights were counted. The average number of fruit per upright, total fruit weight, average berry weight, and percent rot at 0 and 30 days post harvest also were determined.

Cost Comparison

To complement the 1993 cranberry field trial and to determine whether cranberry growers would have an economic incentive to use fish hydrolysate, a cost comparison of liquid fish fertilizer applied through sprinkler systems versus conventional inorganic fertilizers aerially applied in cranberry production was originally planned for Year 1. A literature review was completed. A cranberry grower survey was designed to obtain farm-level data on labor costs, information regarding existing irrigation capabilities, cranberry acreage by cultivar, and data regarding soil type (i.e., level of organic matter). The survey was tested with 4 New Jersey cranberry growers. The cost comparison study was rescheduled to Year 2 when the graduate student who was assisting on the project left to accept a job. The study was subsequently canceled because the literature review revealed previously published cost comparisons (see **RESULTS -Cost Comparison**). This action was proposed in the Progress Report July - December 1994 and subsequently approved by NCRI (Henderson and Strombom 1995e). By canceling the proposed cost comparison study, researchers were able to divert attention to three surveys related to customers and competitors (see **METHODS - Business Development and Marketing**).

Turf Field Trial

A fertility study was initiated in June 1994 on 'Baron' Kentucky bluegrass grown on a sandy loam at the New Jersey Agricultural Experiment Station Horticulture Farm II located in North Brunswick, New Jersey. Two formulations of fish hydrolysate (2-1-0 and 2-1-1) were compared with a popular organic fertilizer, Ringer's Restore (9-4-4), and a commonly used water-soluble inorganic fertilizer (12-4-8). All fertilizers were applied at equivalent rates of 1 pound of nitrogen per 1000 square feet. Two application timings for the hydrolysate and Restore were compared.

The plots were rated for color and clipping yield when mowed approximately once a week. Clippings were collected with a 21-inch wide rotary mower set at 2 or 2.25 inch mowing height. Irrigation was performed to avoid severe drought stress. A randomized complete block design with 4 replications was used. Plot size was 4 by 8 feet.

Organic Vegetable Field Trial

Two certified organic farmers in Cape May County, New Jersey utilized the fish hydrolysate as a source of crop nutrients in the production of tomatoes and other organically grown vegetables and melons. The liquid fertilizer was applied through drip irrigation according to rates recommended by the project team. Soil samples were collected from selected rows throughout the summer and analyzed to track soil nitrogen.

Organic home gardener cooperators were solicited by means of an advertisement placed in the spring issue of the NOFA-New Jersey newsletter (Henderson and Strombom 1994a). More than

two dozen interested gardeners responded and were provided sufficient fish hydrolysate for use in their gardens during the 1994 growing season by Axelsson and Johnson Fish Company. The project team provided technical assistance to the home gardeners in the form of recommended application rates, timings and methods. The gardeners were surveyed by telephone in the fall of 1994 for their satisfaction with application ease, crop yield and crop quality.

Business Development and Marketing Plan

Advice and assistance were provided to Axelsson and Johnson Fish Company in the following areas required to begin commercial production:

a) fertilizer formulation;
b) specification for organic certification;
c) container design and material selection; and
d) legal requirements for fertilizer labeling.

Once these basic technical hurdles were surpassed, the project team turned attention to planning strategies for business and market development. A business and marketing plan was developed which includes company background and situation audit, customer analysis, competitor analysis, environmental analysis, business strategy, technology strategy, and development strategy.

Competitor Analysis

Because essential information for the competitor and potential customers analyses was lacking in the literature, the project team conducted three surveys during the fall of 1994. The competitor analysis was based on two surveys. To characterize nation competition, a survey was faxed to 38 primary and secondary suppliers listed in the "1993-1994 Organic Market Guide: New Jersey" as carrying "fish product fertilizer." Information requested consisted of fertilizer company, location, brand names, nutrient composition, unit quantities available, and pricing.

To determine which brands of liquid fish fertilizer are available in New Jersey, a representative sample of retail stores geographically distributed throughout the state was taken from New Jersey telephone yellow pages and surveyed by telephone. A national agricultural supplier chain - AgWay, two national home improvement chains - Home Depot and Channel Home Center, two fertilizer suppliers; and thirteen independent garden centers were contacted. A total of 24 stores were surveyed. Information requested consisted of brands of liquid fish fertilizer currently stocked, the nutrient composition of each brand, product size and price.

Customer Analysis

The fact that NOFA-NJ has 500 members and 5,500 people interested in organic farming and gardening on its mailing list provides a general measure of the interest in organic home gardening. To gain a better understanding of what organic home gardeners are looking for in an organic fertilizer, a telephone survey was designed to obtain information regarding organic fertilizer usage, brand awareness, sources of information, relative importance of product attributes, and respondent demographics. The survey was conducted by telephone of 155 individuals selected at random from the NOFA-NJ database in November 1994.

RESULTS

Several target markets were identified. Fish hydrolysate is a recognized product in commercial cranberry production and in organic farming and gardening. Controlled tests demonstrated efficacy of the fish hydrolysate comparable to synthetic fertilizer in cranberry production and comparable to other organic fertilizers in staked tomato production. The field trials on turf grass were inconclusive.

Cranberry Field Trials

Related Research

Research results which indicated that using fish hydrolysate on Massachusetts cranberry bogs produced at least as well as those which receive conventional fertilizers (DeMoranville 1988, 1989, & 1990) had to be confirmed in New Jersey given differences in soil characteristics and climate.

Preliminary investigations conducted with fish hydrolysate on *Early Blacks* and *Stevens* cultivars on 4 New Jersey commercial cranberry farms during the 1992 season, indicated that fish hydrolysate presents some challenges as a good regime for cranberry production in New Jersey (Davenport and Provost 1993). The fish hydrolysate used in the 1992 trials differed in nutrient ratio from that used in Massachusetts (Davenport and Provost 1993). The fish hydrolysate material developed for use in Massachusetts for cranberry growers had a 1:2:1 ratio of N:P:K. The New Jersey fish product used in the experiment had a ratio of 4:1:0.1. Cranberry soil and tissue surveys by Davenport and Schiffhauer (1992 unpublished) have shown that New Jersey cranberry bogs are low in P and K levels and supplemental P and K are needed. Thus, the fish fertilizer used in the 1992 experiment did not provide sufficient P and K to meet crop requirements.

It was assumed that the fish hydrolysate used in these trials contained equivalent ratios of nutrients to the hydrolysate used in the Massachusetts trials. As a result, highly elevated levels of nitrogen were used. Excessive nitrogen results in vegetative growth at the expense of berry production (Davenport 1993). This is a particular problem in bogs with higher organic matter content (Davenport and Provost 1993). Therefore, berry yields were depressed in the hydrolysate treatments.

Fruit rot is a serious problem in New Jersey cranberry production. New Jersey cranberries have the highest percent rot in all of the North American cranberry producing areas (Ocean Spray Cranberries Inc., unpublished). This is attributable to warmer climate as compared to other cranberry producing areas. Davenport and Provost (1993) cautioned against using the 4:1:0.1 fish hydrolysate formulation on beds with historically high rot levels.

1993 Field Trial

For the 1993 cranberry field trials on *Early Blacks*, hydrolysate formulation was adjusted to the desired 2-4-2 N:P:K, and application rates adjusted to appropriate levels for the soil condition of the bog used in the experiment. Results of the 1993 field trial indicate that fish hydrolysate produces cranberry yields comparable to inorganic fertilizer (Henderson and Strombom 1995b).

Cost Comparison

Literature review revealed several costs of production studies for cranberries which include fertilizer costs (Engel 1985, Morzuch 1988, Southern New England Farm Credit 1990 & 1991, and Leiby and Marra 1990). Only Morzuch contains a direct comparison of costs associated with liquid fish fertilizer versus conventional granular fertilizer, and the study did not compare aerial versus sprinkler application.

Several trends are providing incentive to cranberry growers to consider hydrolysate as a fertilizers. Synthetic fertilizer costs are rising as are application costs. Recent cranberry fertility studies recommend 3 to 5 applications, depending on the cultivar, of synthetic fertilizer rather than the traditional two applications in order. The reason for the recommendation is to provide sustained availability of nutrients to the crop for optimum fruit production. Fish hydrolysate, being a slow release fertilizer, does not have to be applied as frequently. In fact, recent research at the University of Massachusetts Cranberry Field Station indicates that 20% less nitrogen can be provided if liquid fish fertilizer is used to produce the same yields as conventional fertilizers because of the sustained availability of the nutrients provided. In addition, because it is applied via the sprinkler system, fish hydrolysate application avoids expensive aerial application costs.

Turf Field Trial

Treatments evaluated for color response and fresh clipping yield generally demonstrated that the fish hydrolysate and Ringer's Restore released nitrogen to the turf more slowly than the water soluble, inorganic fertilizer. This response is most likely due to lower soil temperatures inhibiting nitrogen mineralization of organic nitrogen forms. The color response of the turf to both hydrolysate treatments was equivalent to that of the organic fertilizer, although the timing of green-up in mid-summer was slower with the hydrolysate. Clipping yields of the hydrolysate formulations and the organic fertilizer also were similar. As expected, the inorganic fertilizer application resulted in the fastest green-up and highest clipping yields. However, the color ratings for the inorganic fertilizer and the organic fertilizers were quite comparable until mid-autumn when the color resulting from applying the inorganic fertilizer was significantly higher. More detailed results are reported in a separate publication (Murphy 1995).

Organic Vegetable Field Trial

The two organic farmers who used fish hydrolysate during the 1994 growing season reported satisfaction with ease of application. Both farmers experienced problems initially with clogging of apertures in the irrigation strips. Additional screening of the product both at the fish hydrolysate plant and at the farms removed small fragments of bone and resolved the problem.

Crop yield and quality with the use of fish hydrolysate were consistent with previous years' production and previously used organic fertilizers. The tomatoes produced were packed in specially designed 10 lbs. boxes imprinted with "Vine Ripened Organic Jersey Tomatoes" and "NOFA-NJ Certified Organic Jersey Tomatoes." The organic tomatoes were marketed through five retail outlets in the Philadelphia area owned by one of the farmers and under a cooperative project with the Northeast Organic Farming Association - New Jersey and Jersey Fresh Program of the New Jersey Department of Agriculture.

Business Development and Marketing Plan

A model business development and marketing plan for fish hydrolysate determined that aggressive marketing, emphasizing ease of application and organic certification, is the key to business success. Competitive advantage will most readily be achieved by supplying nearby markets where distribution costs will be relatively low. Details of the business development and marketing accomplishments of this project are reported in Henderson and Strombom (1995b).

Organic Certification and Fertilizer Licensing

A pilot hydrolysate plant was constructed at Axelsson and Johnson Fish Company. With the assistance of the project team, Axelsson & Johnson Fish Company was able to consistently produce a fertilizer product of desired nutrient content as verified by an independent laboratory. The product was certified organic by the Northeast Organic Farming Association of New Jersey in the fall of 1993 and the company obtained New Jersey state licensing of the product for sale as a fertilizer shortly thereafter.

Product Package and Label Development

Alternative commercially available container designs were reviewed and assessed. Selection was based on target market applications. The primary criteria were ease of distribution and handling in applying the fertilizer by different target users, and non-reactivity of container materials which would provide for a shelf-stable product. A 30-gallon barrel was selected for use in agricultural markets. The barrel provides for relatively easy delivery of larger volumes of product. A 32-ounce, non-reactive plastic bottle with a self-measuring dispenser was selected for use in home-gardening markets. Accelerated shelf life studies indicate that *Sea Sprout* is stable for up to 2

years if stored within this particular container in a non-diluted state. The self-measuring device reduces direct contact with the fertilizer by the user. This container is unique among liquid fish fertilizer brands currently on the market.

A label was developed to meet legal requirements and provide application recommendations. Labels and packaging were ordered and stocks received in preparation for consumer as well as commercial sales during the 1995 growing season.

Competitor Analysis

Direct competitors of *Sea Sprout* are other fish hydrolysate brands, fish emulsions (a concentrate of fish processing waste water), and soluble fish powder products. Product variations contain seaweed which provides additional desirable trace elements to the fertilizer. The liquid fish fertilizer product class is distinct from bulk organic fertilizers, such as manure and compost, which are turned into the soil as an amendment prior to planting.

Results of the supplier survey indicate that there are a number of liquid and powdered fish fertilizers on the national market. The suppliers closest to New Jersey are Ocean Crest of Gloucester, Massachusetts, Necessary Trading of New Castle, Virginia, Hy-Trous of Woburn, Massachusetts, and North Country Organics of Bradford, Vermont.
Ocean Crest manufactures Neptune's Harvest, a fish hydrolysate with a 2-4-.5 NPK analysis. Neptune's Harvest is available in 5, 55 and 4500 gallon quantities. Ocean Crest also sells a fish and seaweed fertilizer blend in the same quantities. Necessary Trading manufactures SeaMix, a fish emulsion with seaweed with a 3-2-2 NPK analysis. It is available in pint, 1 gallon, and 5 gallon quantities. Necessary Trading also produces Folia-Fish, a concentrated fish powder with a 12-0-1 NPK analysis. No information was received regarding quantities and prices for Hy-Trous and Squanto's Secret.

Although almost all brands of fish fertilizer are available through mail order, only Alaska brand is readily available. The Alaska brand is carried by independent garden centers but not by Agway, fertilizer suppliers, or home improvement centers. Alaska brand is an emulsion, not an hydrolysate.

New England seafood processors are experiencing severe fish supply shortages. The suppliers in New England and Virginia face higher transportation costs than BEA in serving this market.

The national fertilizer industry is well-developed and includes several large, well-established companies such as Ortho and Fertrell which already liquid fish fertilizers. These companies can martial significant marketing resources.

Although there is always a threat of new entrants into the Mid-Atlantic organic fertilizer market, BEA's competitive situation is promising. Other New Jersey seafood processors have not acquired hydrolysate technology and expertise, and BEA has a lead in developing New Jersey

agricultural and consumer markets. Seafood processors in and near the port of Cape May are not likely to enter the market due to BEA's competitive advantage, particularly if BEA accepts their solid fish wastes and, thereby, provides them with a disposal alternative to landfill.

Customer Analysis

The primary target agricultural markets for *Sea Sprout* in New Jersey are for commercial production of cranberries and organically grown vegetables. Fish hydrolysate has been proven effective by research conducted by the University of Massachusetts and Rutgers Cooperative Extension (DeMoranville 1988, 1989, & 1990, and Henderson and Strombom 1995b). Fish hydrolysate has been used as a fertilizer in commercial cranberry production in Massachusetts since about 1990s. There are 3,300 acres of cranberry farms in New Jersey and the majority of the farms are equipped with sprinkler systems. The primary advantage of using fish hydrolysate in cranberry production is that it can be applied, because it is a liquid, via sprinkler systems and, thereby, save on costly aerial application. Likewise, fish hydrolysate can be applied via drip irrigation to tomatoes and other vegetables.

As part of this project, two organic farmers in southern New Jersey used fish hydrolysate during the 1994 growing season for tomatoes and other vegetables and reported good yields. The Northeast Organic Farming Association of New Jersey (NOFA-NJ) certified 33 organic farmers in 1994.

Fertilizer formulation requirements are diverse in agricultural markets. Commercially grown crops require specific NPK formulations, rates and timing of application. Farmers select fertilizer products with specific formulations depending on the specific crop grown and soil conditions. Farmers conduct soil tests relatively frequently to assess nutrient availability in the soil and strive to provide an appropriate nutrient balance for their crops through selection of appropriate fertilizer formulations and application rates.

In contrast to the organic farming market, home gardeners tend to purchase a standard fertilizer for a broad range of applications such as vegetables, flowers, or lawn. They conduct soil tests relatively infrequently and, in general, are poorly informed regarding nutrient requirements of specific plants and the NPK analysis of the fertilizers they purchase. They tend to rely on the application rate recommendations provided on product labels.

A survey of organic home gardeners was conducted in November 1994 to identify potentially important consumer attitudes and buying behavior relevant to liquid fish fertilizer (Henderson and Strombom 1995c). The results suggests that increasing market share for liquid fish fertilizer among home gardeners would require considerable effort to raise awareness of the product and overcome buyer resistance due to lack of experience. The dominant use of bulk fertilizer indicates that pre-plant application of fertilizer is the general practice; yet liquid fertilizer is most often used as a side dressing. Moreover, even gardeners purchasing fish fertilizer had almost no brand awareness.

All consumers surveyed placed a high importance on the organic characteristics of the product and on the product being environmentally safe. Convenience factors, such as ease of application and availability of the product through local gardening centers were important. The survey indicates that organic gardeners are interested in new products and sharing of information.

The organic gardeners surveyed had all joined NOFA-NJ, a statewide association of farmers and home gardeners interested in organic methods. They report that they are more likely to seek and give gardening advice than others they know. Personal experience, word-of-mouth communication, and articles in organic gardening magazines are important sources of information. These gardeners are more responsive to education than to commercial promotion of products. This suggests that suppliers of liquid fish fertilizer should utilize organic gardening associations and expert testimony in respected organic gardening magazines as means of increasing sales rather than advertisements to promote their product.

Direct mail is not an important means of fertilizer purchase. This is most likely because organic home gardeners primarily buy and use bulk fertilizer for pre-planting soil preparation. The gardeners look to purchase in their local home gardening centers. To increase liquid fish fertilizer sales, suppliers should consider increasing availability through local gardening centers.

Organic home gardeners do not appear to be particularly price sensitive for a product that is organic and environmentally safe.

TECHNOLOGY TRANSFER/OUTREACH

Technology transfer is a major component of the project to examine the efficacy and marketability of liquid fish fertilizer in southern New Jersey. Seafood processors in coastal and Great Lake states around the country face rising solid waste disposal costs and reduced waste disposal options as landfill space becomes more limited. Seafood processors will benefit from the adoption of hydrolysate technology by converting a costly solid waste disposal problem into a revenue-generating by-product.

The keys to processor adoption of hydrolysate technology for producing liquid fish fertilizer are to identify potential markets through agricultural and home gardening field trials and to develop an effective marketing strategy to develop target markets. The field trials and model marketing plan developed as part of this project will facilitate the adoption of fish hydrolysate technology by seafood processors. The principal investigators have combined expertise in product development, business management, market development, and agriculture production. Both are extension faculty with Rutgers Cooperative Extension and New Jersey Agricultural Experiment Station, institutions dedicated to applied research and public outreach. Rutgers researchers assisted Axelsson and Johnson Fish Company in researching fish hydrolysate technology and establishing a production facility. A key feature of this project is the close working relationship between Rutgers researchers and the Axelsson & Johnson Fish Company. Information has been exchanged regularly through in-person and telephone communication during formulation development, the organic certification procedure, and field trials.

Team members met with Northeast Organic Farming Association of New Jersey (NOFA-NJ) representatives regarding organic fertilizer certification. Information about the cranberry field trial was presented to the American Cranberry Growers Association at its winter meeting 1993. A technical report summarizing the results of the cranberry field trial and a fact sheet describing the procedure for applying liquid fish fertilizer through the sprinkler systems were developed and distributed to Ocean Spray cooperative members and independent cranberry growers in New Jersey (Henderson and Strombom 1995b & c).

Team members worked directly with two south Jersey farmers who utilized *Sea Sprout* during the 1994 growing season for the commercial production of organically grown tomatoes. A fact sheet describing the procedure for applying liquid fish fertilizer through drip irrigation was developed and distributed to certified organic farmers in New Jersey, NOFA-NJ, and Rutgers Cooperative Extension agricultural agents in 21 counties of New Jersey (Strombom and Henderson 1995). A technical report regarding the results of the turf trial was produced and findings were presented at the 1993 New Jersey Turfgrass Expo in December 1993 (Murphy 1995).

A model business development and marketing plan for liquid fish fertilizer and a technical report summarizing results of a survey of New Jersey organic home gardeners were produced (Henderson and Strombom 1995a & d).

The this final project report and the model business development and marketing plant were distributed to the Pell Library and all coastal state Sea Grant College Programs, the primary federal program for providing extension services to seafood processors, by the New Jersey Sea Grant College Program.

A feature article about this project in NCRI News resulted in inquiries from seafood processors in Oregon and Alaska (Henderson and Strombom 1994c). An article in the summer 1994 issue of NOFA/NJ News, the newsletter of the Northeast Organic Farming Association of New Jersey, reached over 5,000 readers interested in organic farming and gardening throughout New Jersey and the Mid-Atlantic/New England region (Henderson and Strombom 1994d). Dozens of inquiries were received by interested home gardeners. Information about the product and potential applications was provided by team members and product requests were referred to Axelsson & Johnson which shipped requested volumes directly to new customers. Two additional articles about the project appeared in The New Jersey Farmer, the leading agricultural newspaper in New Jersey, and The Jersey Shoreline, newsletter of the New Jersey Sea Grant Program (Henderson and Strombom 1994e & f).

An educational exhibit, *Development of New Jersey Liquid Fish Fertilizer*, which highlights activities and accomplishments of this project, was developed. The educational exhibit was displayed as part of a commercial booth, staffed cooperatively with Axelsson & Johnson Fish Company at the popular Northeast Organic Farming Association -New Jersey annual fair in Pennington, NJ on September 17 & 18, 1994.

A slide set summarizing the development of a liquid fish fertilizer in New Jersey was developed. The slides were used in presentations at the 39th Annual Atlantic Fisheries Technological Conference and Rutgers Cooperative Extension Annual Conference (Henderson and Strombom 1994c).

PROJECT DIRECTOR'S ASSESSMENT

OUTCOMES

This project achieved its objective of assisting a seafood processor in the port of Cape May in commercializing hydrolysate technology to resolve its solid waste disposal problem. The Axelsson and Johnson Fish Company has installed a commercial scale hydrolysate plant and has formed a new company, BEA, Inc. to manufacture and market fish hydrolysate as a certified organic liquid fertilizer. BEA has operated the plant at a pilot-scale for the two-year duration of the project. The branded product, *Sea Sprout*, is licensed by the New Jersey Department of Environmental Protection as a fertilizer, and is certified organic by the Northeast Organic Farming Association of New Jersey (NOFA-NJ). The spring of 1995 is the first season of commercial production.

A&J Fish Company has a wholesale fish business which processes more than 100 species of fish that come into their docks through independent fishermen on a daily basis and distributes about 15 million pounds of fish a year. BEA reports that the current plant has the capacity to convert 6,000 pounds of waste into hydrolysate daily.

The development of this new waste processing capability has contributed significantly to the reduction of waste disposal costs. Solid waste from seafood processing have traditionally been disposed of in landfills. Landfill tipping fees in southern New Jersey counties, where New Jersey seafood processing is concentrated, have increased dramatically in recent years adding significantly to operating costs (Henderson and Strombom 1992). Seafood processing waste is excluded from current food recycling programs in Cape May County. In addition, the single landfill in Cape May County is scheduled to be closed in the next few years. Therefore, landfill is being eliminated as a disposal option. A&J has also relied on swine farmers to take its solid waste. However, there is a decline in local hog production due to competition from large-scale operations in other parts of the country with lower costs of production. Expected expansion of markets and manufacturing will bring BEA to its goal of becoming the dominant supplier of fish hydrolysate in the Mid-Atlantic region and a profit center for the parent company.

At the present time, BEA employs three people, one in management and production oversight, one in manufacturing, and one in market development.

The success of this project was due in large measure to the partnership between Land-Grant Extension and private sector partners. Each brought complementary resources and expertise to solving this real-world problem. The seafood processor made capital investment in the plant construction, product manufacturing, and package development. Extension technical assistance was particularly helpful in appropriate technology identification, product formulation, certification procedures, product testing at university research facilities, and market development. Through the Extension Service, farmers and home gardeners were recruited to

participate in field trials. In addition, the support of agricultural organizations such as the Northeast Organic Farming Association of New Jersey, the New Jersey Turfgrass Association, and Blueberry/Cranberry Research Council was facilitated through existing Extension contacts.

The primary unanticipated outcome was a change in the target market for *Sea Sprout*. The original target market anticipated was commercial cranberry growers in New Jersey based on the experience of fish hydrolysate producers in New England. However, the enthusiastic response of organic farmers and home gardeners in New Jersey has resulted in a shift in market focus.

FUTURE GOALS

Consistent with our work and technology transfer plans, a close relationship will be maintained between BEA, Rutgers Cooperative Extension, and the industry groups with which we have cooperated during the project. This project has become self-sustaining with the commercialization of the hydrolysate operation in New Jersey. The growth of the company will depend primarily upon the development of market demand and profitability of the operation. Increased employment opportunities, manufacturing capacity, business expansion and economic stability are anticipated as the business grows.

DISSEMINATION

As described more fully in the Technology Transfer/Outreach section of this report, extension publications have been disseminated to cranberry growers, turf farmers, organic vegetable growers, and home gardeners in New Jersey. Feature articles have appeared in *NOFA-New Jersey News*, *New Jersey Farmer*, and New Jersey Sea Grant's *The Jersey Shoreline*. An educational exhibit was displayed at the popular NOFA-NJ annual fair in Pennington, New Jersey, and product samples were distributed to 500 interested gardeners. Research results were disseminated to industry and extension professionals at the Atlantic Fisheries Technological Conference, New Jersey Turf Expo, Rutgers Cooperative Extension's annual conference, and the American Cranberry Growers Association semi-annual meeting.

National dissemination has been achieved through an article about the project in the *NCRI News* and publication distribution of this final project report and the model business development and marketing plan by New Jersey Sea Grant to the Pell Library and all coastal state Sea Grant College Programs, the primary federal program for providing extension services to seafood processors.

The technical and capital investment requirements of implementing a fish hydrolysate facility are not prohibitive. Technical specifications for equipment and formulation are available in the literature, and this project provides guidance to market development. The successful adoption of fish hydrolysate production depends upon a consistent supply of raw material, meeting the

fertilizer standards set by state regulatory agencies, and aggressive market development.

State and national Extension and industry information distribution channels have been utilized in disseminating project related results to industry and Extension professionals. Commercialization of *Sea Sprout* will expand dissemination through advertising media.

OTHER

One important lesson of this project was that it is essential to assemble a interdisciplinary team with appropriate expertise to address multifaceted problems. This expertise may come not only from one's own academic institution but from other universities, industry groups, and the governmental agencies.

Because of busy schedules and multiple obligations, flexibility is needed on the part of all team members. Project management must deal with emerging problems expeditiously in order to insure that team members responsible for project components stay on schedule.

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APPENDIX I

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APPENDIX II

SUMMARY OF EXTENSION MATERIALS
Efficacy and Marketability of Liquid Fish Fertilizer in Southern New Jersey

The following extension materials were developed with funding from the National Coastal Resources Institute, pursuant to NOAA contract number ST93.203-5630-06; NOAA Office of Sea Grant, Department of Commerce, pursuant to grant number NA89AA-D-SG057 (Project # A/A-1); and the 1993-1994 Special Initiative in Solid Waste Management of the New Jersey Agricultural Experiment Station.

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