U.S. Department of Agriculture (USDA) National Institute of Food and Agriculture (NIFA)

Promote sustainable Agriculture Concepts in Education through multidisciplinary Research and Pedagogical Trainings (PACE)

Texas A&M University-Kingsville

Summer 2024 Program

Cohort #1: June 17-July 3, 2024 or Cohort #2: July 10-July 26, 2024

Project #1: Fundamental Understanding of Tearing and Fracture Behavior of Food Packaging Films

Faculty Advisor: Dr. Mohammad Motaher Hossain, Mechanical and Industrial Engineering

***i. Motivation*:** Polymeric films have been extensively used in packaging industries with applications include packaging film for frozen products, shrink film for transport packaging, food wrap film, packaging bags, fill and seal packaging film, and so on. Retaining structural integrity of food packaging films is a major concern for preservation of food quality and safety. A scratch on food packaging film can cause it to tear prematurely or compromise its barrier properties, which may ruin the product inside. Thus, significant research efforts are currently undergoing to study various fracture modes of food packaging films. However, difficulty in characterizing various fracture process zones *in-situ* hinders fundamental understanding of fracture behavior of polymer films. Fundamental understanding of tearing and fracture behavior will enable improving the toughness of food packaging films, extending the shelf-life and improving the food safety.

***ii. Project Description*:** The study will primarily focus on linear low-density polyethylene (LLDPE), which is one of the most widely used material for food packaging films. Various tearing and fracture modes of LLDPE films with variation in film thickness will be studied, using: i) ASTM standard scratch testing, using an in-house scratch machine; ii) Double-edge-notched tension (DENT) testing following the Essential Work of Fracture (EWF) method using an in-house universal testing machine (MTS Criterion Model 45); and iii) ASTM standard mode III out-of-plane tearing test, using the MTS universal testing machine. The photoelastic imaging technique will be used to understand the fracture process zones *in-situ* for the DENT EWF and tearing tests. Optical microscopy (OM) will be performed to investigate the fracture mechanisms.

***iii. Research Training for the Participants*:** Two teachers in each cohort will work together in this project. They will work together to conduct scratch, DENT EWF, and tearing tests on polymer films. They will also work together to conduct *in-situ* photoelastic observation and OM to study different failure modes. Different cohorts will choose different variation of LLDPE (e.g., processing variation, such as blow-up ratio (BUR), draw down ratio (DDR), etc.) and other polymer films (e.g., polypropylene (PP), polystyrene (PS) and polyamide (PA) films).

Project #2: Basics of Soil and Water Conservation for Agriculture and Ecosystems
Faculty Advisor: Dr. Benjamin Turner, Agriculture and Natural Resource Management

i. Motivation**:** Excessive sediment concentrations resulting from landscape scale erosion processes can adversely affect water quality and fish habitat and lead to environmental determination of surface water sources being impaired or threatened. The objectives of this project are to: 1) Build a demonstration instrument and teaching/extension protocol for rainfall-erosion simulation in the field or lab, and 2) Construct curriculum material for student and instructor use.

ii. Project Description**:** Erosion and runoff are physical processes that must be managed like other agroecosystem processes. The erosion process is initiated by one of two forces: wind or water impact. Wind erosion can begin with light wind that rolls soil particles along the surface (surface creep) through to a strong wind that lifts and detaches large volume of soil particles (saltation) into the air to create dust storms (suspension). On the other hand, water erosion is initiated by the kinetic energy of rain drops to the soil surface, which if unimpeded, detaches and splashes soil particles making them available to be carried downslope in overland flow, rills, or eventually gullies. A rain droplet's kinetic energy is one-half of its mass times velocity squared. A soil's susceptibility to or risk of detachment during rainfall events can be evaluated by its "erosivity". The project aims to build an erosion demonstration and related curriculum material around agricultural and conservation efforts used to minimize risks of soil erosion.

iii. Research Training for the Participants**:** Participants will learn about the trade-offs scientists must make in designing research laboratories and experiments, and considerations for communicating research results to non-scientific audiences. Participants will also triangulate and link research processes and insights and extension communication plans (resulting from objective 1) with existing STEM learning outcomes they currently teach for in these classrooms. Appropriate reading material, supplemental videos, and instructor resources will then be tailored to those outcomes.

Project #3: Design Elevated Solar Panel Systems for Different Types of Agricultural Lands
Faculty Advisor: Dr. Hua Li, Mechanical and Industrial Engineering

i. Motivation**:** There are approximately 127 million acres of agricultural land in Texas, which have the potential to house solar energy systems to generate a diversified supplemental source of income for farmers. However, solar panels located on agricultural land are more agriculturally disruptive. Preliminary studies have shown some benefits of agrivoltaics, or the growing of crops beneath elevated solar panels. The objective of this project is to design different types of elevated solar panel systems for various agricultural lands and products.

ii. Project Description**:** This project focuses on investigating two of the major challenges of agrivoltaics: 1) shadows caused by solar panels affecting the growth of agricultural products, and 2) solar panel supporting structures becoming obstacles during harvesting processes. Three major research tasks will be completed: Task #1: Studying shadow modeling in agrivoltaics. The size, depth, and orientation of shadows are affected by various factors, including properties of solar panel systems (size, height, mounted angle, etc.) and characteristics of solar radiation. Task #2: Investigating the operation of different agricultural lands and products. The timing and methods of planting and harvesting different agricultural products that are popular in Texas will be investigated, which will be further compared with the solar radiation levels based on the locations.

Task #3: Design different elevated solar panel systems to maximize the benefits of agrivoltaics. Based on selected location and agricultural land and product, the conceptual design of the elevated solar panel systems will be created with 3D modeling software, such as SketchUp.

iii. Research Training for the Participants**:** Two teachers will work together in this project. One teacher will focus on Task #1 while the other teacher will focus on Task #2. Both teachers will work together on Task #3. Different cohorts will choose different agricultural lands or products.

Project #4: Developing Decision Making Support Systems for Sustainable Agriculture Product Supply Chain

Faculty Advisor: Dr. Kai Jin, Mechanical and Industrial Engineering

i. Motivation**:** Improving supply chain efficiency and sustainability has been a challenge in the decision making process, especially to agriculture products which have unique features compared to other products. The usage of modern high-tech communication tools generated huge amount of data and information that can be used in the decision making process. However, there is lack of a systematic platform that can help the user visualize and effectively use the data.

ii. Project Description**:** Engineering economic analysis methods and tools are part of the approaches to process the available big data on agriculture and generate valuable information to assist the decision making process. Discounted costs and benefits over a fixed period of time will be compared. The ratio of total benefits to total cost (benefit-cost ratio) or equivalently, the total net benefits (net present value) will also be evaluated. Furthermore, goal seeking and sensitivity analysis will be used to address the uncertainty in the problems. The steps to be used in this project to estimate the economic consequences of a decision can be summarized as: a) Define the problem and the objective; b) Identify feasible alternatives for accomplishing the objective, taking into account any constraints; c) Select a method or methods of economic analysis; d) Select a technique that accounts for uncertainty and/or risk; e) Compile data and make assumptions called for by the economic analysis method(s) and risk analysis technique; f) Compute a measure of economic performance; and, g) Compare the economic consequences of alternatives and make a decision, taking into account any non-quantified effects and the risk attitude of the decision maker.

iii. Research Training for the Participants**:** Two teachers will work together on the literature survey and data search. The teachers will then define their own research problem and objective within the scope to improve agriculture product supply chain efficiency and sustainability. Both teachers will be trained with different economic analysis methods and tools. Each teacher will implement different methods and tools on the data obtained from USDA websites, and will evaluate their effectiveness and efficiencies on agriculture applications.