Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2018 ENRTF Work Plan (Main Document)

Today's Date: 12/15/17

Date of Next Status Update Report: 01/31/19

Date of Work Plan Approval: 06/05/2018

Project Completion Date: June 30, 2021

Does this submission include an amendment request? __

PROJECT TITLE: Develop Biomulch to Replace Plastic Soil Covering in Vegetable and Fruit Production to Increase Yield and Reduce Waste

Project Manager: Dr. Paulo Paglairi

Organization: University of Minnesota

College/Department/Division: CFANS/Department of soil water and climate/Southwest Research and Outreach Center

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City/State/Zip Code: Lamberton/MN/56152

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Web Address:

Location: Statewide

Total Project Budget: $310,000

Amount Spent: $0

Balance: $310,000

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 08b

Appropriation Language: $310,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to develop and test the performance of biodegradable biomulch to increase yield, conserve water, suppress weeds and pests, add nutrients to the soil, and replace large amounts of nonrecyclable and nondegradable plastic used in vegetable and fruit production. This appropriation is available until June 30, 2021, by which time the project must be completed and final products delivered.

I. PROJECT STATEMENT:

This LCCMR proposal is an interdisciplinary, interinstitutional (Agricultural Utilization Research Institute – AURI – and the University of Minnesota) partnership focused on developing a material that would replace petroleum derived polyethylene plastic films in vegetable and fruit production in MN. Plastic films are indispensable in vegetable production as they help to increase yield, conserve water while suppressing weeds and pests, and serve as pathogen protection for the plants. Unfortunately, the plastic is largely non-recyclable, often chemically contaminated (herbicide and pesticide), labor intensive to remove, and overall a source of environmental pollution. Therefore, a biodegradable replacement is needed for cleaner vegetable and fruit production in MN, and potentially nationwide. Such new material must be engineered to achieve three critical functions:

- be a soil cover that provides all the benefits the currently used non-degradable plastic provides
- be biodegradable so that at the end of the season the material can be incorporated into the soil
- be a nutrient source for plants during the years following incorporation as it slowly decomposes

In this project we will test and refine a product (BioMulch) which will meet all of the requirements stated above. The product will be sprayed on top of the soil just prior to transplanting the vegetables, and within a couple of hours the product will harden to seal the beds and start working in a similar manner as traditional plastic. At the end of the season in the fall, the product will be tilled into the soil so that it can start to naturally decompose. Therefore, it is important the BioMulch be designed in a way that it is hard enough to function like a plastic during the season, but then decompose when mixed into the soil. This project will also be used to generate all of the information related to applicability of the product, ease of distribution, longevity, decomposition rate, nutrient release rate, and its horticultural impacts. The results will be publically disseminated through applicable peer reviewed journal articles, the University of Minnesota Research and Outreach Centers (ROCs), AURI online and print publications including AG Innovation News and as a component of public field days at AURI and/or the ROCs.

II. OVERALL PROJECT STATUS UPDATES:

First Update January 31, 2019
Second Update June 30, 2019
Third Update January 31, 2020
Forth Update June 30, 2020
Fifth Update January 31, 2021
Final Update June 30, 2021

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Incubation study for initial assessment of BioMulch decomposition rate

Description:

In this activity, the BioMulch formulations developed at AURI will be refined through collaborative testing of the products in small greenhouse trails and laboratory soil decomposition testing. The primary goals of this activity are to determine the optimal formulation composition, establish standardized operating procedures (SOPs) to be used for the remainder of the project and to determine the degradation and nutrient release rate of BioMulch after mixing into soil.

The BioMulch smart material base formulations have already been developed in the laboratory at AURI. Testing is required to establish application protocols and confirm the primary functionality of the materials in

order to select the final material to be used in the greenhouse trials and field plot tests. AURI will provide small batch formulations of different compositions for rapid analysis in the laboratory at southwest research and outreach center (SWROC) testing site location to determining soil coverage, soil temperature as a result of solar absorption and stability of BioMulch in different conditions. The initial testing effort will provide the whole team experience with the products and time to establish SOPs for the testing locations. Additionally, the results will provide the data needed to select the final formulation for further study. Analytical analysis will be performed at the SWROC and AURI with any required formulation modifications completed by AURI. The formulation found to have the best performance will enter into further decomposition studies to begin the long-term field experiments testing product decomposition in soil.

The team will set up incubation studies where soil and small pieces of BioMulch will be mixed together and placed in an incubator with controlled temperature and moisture. Soil will be added at about 100 grams while BioMulch will be added as small strips of 1 to 2 cm and weighing approximately 1 to 2 grams. The incubation study will be carried on for about 10 weeks, or longer if needed, and visual inspection will be done to determine the rate of decomposition. In this activity, we will also determine the rate of nutrient release as BioMulch decomposes by using tradition soil tests used for the determination of available phosphorus and nitrogen. We expect that about two sets of incubation studies will be sufficient to complete the initial benchmarking assessment. We will use the results gathered in these incubation studies to determine how to perform Activities Two and Three. Expected starting day for the first incubation study is November 1st 2018 after the initial formulation testing has been completed, the soil samples gathered, dried and sieved for the decomposition study.

ENRTF BUDGET: $52,000

Outcome	Completion Date
1. Final BioMulch composition identified and standard operating procedures completed	October 31, 2018
2. Known decomposition rate of BioMulch	March 31, 2019
3. Known nutrient release rate as BioMulch decomposes	March 31, 2019

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Final Update June 30, 2019

ACTIVITY 2: Greenhouse study for initial assessment of BioMulch, plants, and soil interaction and plant growth response

Description:

Our objective with this activity is to determine how BioMulch, plants, and soil interact and what the potential detrimental effects could be so that improvements can be done prior to the start of the larger field trials. The greenhouse study will be conducted in the fall and winter months of 2018 and, if needed in 2019 so that the product can be refined for the field trials. Initially the greenhouse study will mimic the incubation study with a few differences. Larger pots will be used which will accommodate more soil, as much as 1.5 kilograms; plants will be grown so that we can assess the interaction effect of plant and soil on the decomposition rate of the BioMulch. Tomatoes, peppers, and strawberries will be the test crops for this phase of the study. Plants will be grown for as long as possible to assure enough yield is recorded. In addition, this phase of the study will assess the effectiveness of the BioMulch at supplying plants with nutrients while it decomposes. The experimental design in the greenhouse will be a completely randomized block design with four replications per treatment. To determine how much nutrients are coming from the BioMulch there will be pots that will be treated with commercial fertilizer so that a yield response curve to N and P can be developed. Nitrogen rates will vary from 0 to 200 lbs per acre and P rates will vary from 0 to 100 bls per acre. During the growing season water will be added to assure it is not limiting to plant growth. At the termination stage, soil samples will be collected for nutrient analysis for soil available N and P. The winter of 2019 will provide an additional opportunity to refine the BioMulch formulation and collect additional testing after the data has been collected and analyzed from the first field trial growing season.

ENRTF BUDGET: $68,000

Outcome	Completion Date
1. Nutrient release from BioMulch to plants determined	March 2019
2. Plant yield when BioMulch is used as a fertilizer source	March 2019
3. Effects on plants of using BioMulch as a soil cover	March 2019
4. Refinement formulation from results of first field trial season (if needed)	March 2020

First Update June 30, 2019
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ACTIVITY 3: Field trials for in field evaluation of BioMulch effectiveness as a plastic replacement

Description:

The field trials will be implemented in the spring of 2019 after the incubation and greenhouse studies are concluded and will be continued until the fall of 2020. The field study will be conducted at the Southwest research and outreach center at Lamberton and at the southern research and outreach center in Waseca, MN. The same plots will be used in the second year so that we can assess the nutrient release from the BioMulch as it decomposes. Field trial will be conducted in the open are as well as in the high tunnels as both practices rely heavily on the use of soil plastic covers. In the field study BioMulch will be applied a differing thickness (e.g. 2, 4, and 6 mm but the proper range will be determined during the incubation and greenhouse studies) to assess its ability to stop weed growth; in addition to provide good soil cover, and the desired amounts of nutrients. However, it is not intended that BioMulch will supply 100% of the crops demand for nutrients. This research is being developed to determine how much nutrient can be delivered as the BioMulch decays. We expect that BioMulch will perform as well as ordinary plastic films in terms of stopping weed emergence. Therefore, plots with plastic films will also be used for direct comparison. We will monitor for the effectiveness of the BioMulch in stopping weed emergence by visual weekly inspection which will also aid in assessing overall integrity of the product. Nutrients will be added in the first year as inorganic fertilizer to supply the crops needs for N, P and K. In the second year, different levels of fertilizer will be added to different plots so that we can determine how much fertilizer is available to crops from the BioMulch under field conditions. The experimental design for the field trials will be a completely randomized block design with four replications for each treatment. The crops tested will be the same as in the greenhouse study, tomato, peppers, and strawberry in both years and crop rotation will be used to avoid diseases in the second year as can be observed in mono-cropping tomatoes and other *Solanaceae*.

To determine how much nutrients are coming from the BioMulch there will be pots that will be treated with commercial fertilizer so that a yield response curve to N and P can be developed. Nitrogen rates will vary from 0 to 200 lbs per acre and P rates will vary from 0 to 100 bls per acre. Water will be provided by drip tape irrigation which will be installed prior to the BioMulch being sprayed onto the plots. The BioMulch will sprayed as a liquid which solidifies a few minutes after being applied. Two methods for creating the opening for transplanting the seedlings will be used: i) a small opening will be done after the materials solidifies; ii) small containers (2 to 3 inches wide) will be placed where the plants will go prior to spraying the BioMulch and removed soon after the BioMulch is sprayed but prior to hardening.

After the harvest in each year, we will collect soil samples to assess the BioMulch decomposition as well as nutrient availability at the end of the season. Produce yield will also be monitored every year and will be the main parameter used to assess the effectiveness of the BioMulch in comparison with yields obtained by using regular plastic. After the first year data is gathered the team will assess the results and implement any necessary formulation adjustments which will be tested in the greenhouses prior to implementation in the field in the second field trial demonstration.

ENRTF BUDGET: $ 200,000

Outcome	Completion Date
1. Effectiveness of BioMulch as a weed barrier	October 2020
2. Produce yield when BioMulch is used as a soil cover	October 2020
3. Assessment of soil properties after BioMulch is used	March 2021

First Update January 31, 2020
Second Update June 30, 2020
Third Update January 31, 2021
Final Update June 30, 2021

IV. DISSEMINATION:

Description:

It will be important that Extension events be developed to highlight the findings of this research. Activities 1 and 2 do not have any direct need for dissemination to the public, as those activities are to guide the larger field trial which will be generating all of the needed information for guidelines development. The results of the field trial will be publically disseminated through applicable peer reviewed journal articles, the University of Minnesota Research and Outreach Centers (ROCs), AURI online and print publications including AG Innovation News and as a component of public field days at AURI and/or the ROCs.

First Update January 31, 2020
Second Update June 30, 2020
Third Update January 31, 2021
Final Update June 30, 2021

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview: See attached budget sheet

Explanation of Capital Expenditures Greater Than $5,000: N/A

Explanation of Use of Classified Staff: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours: 1,768	Divide by 2,080 = TOTAL FTE: 0.85

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours: 624	Divide by 2,080 = TOTAL FTE: 0.30

B. Other Funds:

SOURCE OF AND USE OF OTHER FUNDS	Amount Proposed	Amount Spent	Status and Timeframe
Other Non-State $ To Be Applied To Project During Project Period: *N/A*			
	$ *N/A*	$ *N/A*	
Other State $ To Be Applied To Project During Project Period: *N/A*			
	$ *N/A*	$ *N/A*	
Past and Current ENRTF Appropriation: *N/A*			
	$ *N/A*	$ *N/A*	
Other Funding History: *N/A*			
	$ *N/A*	$ *N/A*	

VI. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
N/A			

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Dr. Forrest Izuno	Professor	University of Minnesota	Help with data interpretation
Dr. Vincent Fritz	Professor	University of Minnesota	Help with data interpretation

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

The long-term implementation of this study will be adoption of the new technology by growers in the state replacing currently used petroleum derived plastics. It will be important that Extension events be developed to highlight the findings of this research. The results will also be publically disseminated through applicable peer reviewed journal articles, the University of Minnesota Research and Outreach Centers (ROCs), AURI online and print publications including AG Innovation News and as a component of public field days at AURI and/or the ROCs.

VIII. REPORTING REQUIREMENTS:

- **The project is for 3 years, will begin on July/1/2018, and end on June/30/2021.**
- **Periodic project status update reports will be submitted January/31 and June/30 of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2021.**

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet
D. Acquisition, Easements, and Restoration Requirements
E. Research Addendum

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2018 Budget Spreadsheet

Project Title: BioMulch to Replace Plastic Soil Covering in Vegetable and Fruit Production to Increase Yield and Reduce Waste
Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 08b
Project Manager: Paulo Pagliari
Organization: University of Minnesota
College/Department/Division: CFANS/Department of soil water and climate/Southwest Research and outreach center
M.L. 2018 ENRTF Appropriation: $310,000
Project Length and Completion Date: 3 years, June 30, 2021
Date of Report: 2/15/18

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	TOTAL BUDGET	AMOUNT SPENT	TOTAL BALANCE
BUDGET ITEM			
Personnel (Wages and Benefits) - Overall	**$161,227**	$0	**$161,227**
Project Manager Paulo Pagliari responsible for overall project management. 0.1 FTE per year. Salary at $11,202 and fringe at $2,812 (Total estimated amount $42,042)			
U of M Research Technician reponsible for sample collection and preparation at 0.75 FTE for salary request at $40,620.80 and $11,048.86 fringe (Total estimated amount $119,185)			
Professional/Technical/Service Contracts			
AURI Project Coordinator responsible for project coordination with AURI 10% FTE for salary at $40/hr and fringe at $15/hr (27%), total for three years $33,330.	**$33,330**	$0	**$33,330**
AURI Research Engineer responsible for application technology at 10% FTE at $40/hr and fringe at $15/hr (27%), total for two years $22,220.	**$22,220**	$0	**$22,220**
AURI Research Chemist responsible for formulation technology 10% FTE at $40/hr and fringe at $15/hr (27%), total for two years $22,220.	**$22,220**	$0	**$22,220**
Equipment/Tools/Supplies			
Ingredients for three demonstration sites (100 ft x 3 ft each) total $10,409. Ingredients for formulation refinement and long term decomposition studies $5,359.	$15,469	$0	**$15,469**
Nutrients for production of biomulch at $1,000 per year.	$3,000	$0	**$3,000**
Sample Analysis at $40 per samples to determine the rate of biotarp degradation and nutrient availability (40 samples at each of 2 sites for 3 years, total 240 samples)	$9,600	$0	**$9,600**
Moisture and temperature probes, 30 per location at $250 per probe; total $15,000 for all three ROC locations. 6 dataloggers at $1,000 each per location; total of $12,000 for all three ROC locations.	$27,000	$0	**$27,000**
1 Helium (at $400.00 each) and 1 Oxygen (at $300.00 each) gas cylinders required for carbon nitrogen and sulfur analysis. Total of $700.00 per year.	$700	$0	**$700**
Travel expenses in Minnesota			
In state travel to maintain plots and collect soil samples at the different locations being managed. Estimated 4,000 miles per year, for 20 (weekly travel during May-Spring) x 200 miles round trip from Lamberton to Waseca. Travel estimated at $0.535 per mile to a total of $2,140 per year.	$4,280	$0	**$4,280**
In state travel to plots for applications, sample aquisition and for project meetings estimated average 455 mile round trip and 15 trips per year at $0.535 per mile, total $11,050.	$10,954	$0	**$10,954**
COLUMN TOTAL	$310,000	**$0**	**$310,000**