

South Dakota Nutrient Research and Education Council (NREC) Project Interim Report

Title: Application of biosolid-based nitrogen control release fertilizers to improve nitrogen use efficiency of corn production and soil health in South Dakota

PI: Lin Wei,

Co-PIs: Jason Clark and Yajun Wu

Reporting Period: January 1st, 2023 – June 30th, 2023

Date of Report: 7/1/2023

Written By: Lin Wei

Executive summary:

Nitrogen (N) fertilizer is essential for maintaining soil fertility and corn productivity. However, overuse, run off, and/or leaching loss of synthetic chemical nitrogen fertilizers, such as urea, ammonium nitrate, ammonium sulfate, etc., have resulted in low nitrogen use efficiency (NUE), high production cost, and environmental concerns in farming practices. This project aims to develop an effective and affordable biosolid-based control release nitrogen fertilizer (BCRNF) to improve corn yield while minimizing environmental impacts. This is the second year of continual research on the BCRNF project that was originally started on January 1st, 2022. The research team has utilized their proprietary BCRNF technology to fabricate BCRNF samples for investigating the BCRNF effectiveness on corn growth and soil properties through the ongoing greenhouse and field trials. The major progresses of the first 6 months in the project year of 2023 are summarized but not limited to:

- 1) Utilized the pilot scale BCRNF production line established in our labs to produce 500 lbs of BCRNF samples for the second-year greenhouse and field trials.
- 2) A greenhouse trial was carried out to investigate the responses of corn growth on the 4th generation BCRNF.
- 3) Two corn field trials are being conducted to examine the responses of corn yield on the BCRNF samples in cases of till and non-tillage conditions at two sites: southeast farm (Beresford, SD) and research farm (Brooking, SD) respectively. Hundreds of BCRNF, soil, corn plant samples have been collected, stored, and/or processed for the analyses of N release, N sources, total N, soil microbiology, biomass, etc.
- 4) Investigated the responses of spring wheat yield on BCRNF in greenhouse trials.
- 5) Integrated precision fertilization research and college education programs for dissemination of the new knowledge and BCRNF technologies. 35 undergraduate students in the classes of BOT 327/L (Plant Physiology) and 7 graduate students participated in the BCRNF project.
- 6) Recruited two new PhD students to participate in the BCRNF research.
- 7) One manuscript under reviewing, and 12 oral/poster presentations will be presented in the national and international conferences (ASABE 2023 AIM and S-1075 USDA multi-state project annual meeting on July 9 – 14, 2023).

Project Objectives:

- 1) Optimize BCRNF technology for corn growth through greenhouse trials.
- 2) Evaluate BCRNF effectiveness on corn productivity through field trials.

3) Evaluate economic feasibility of BCRNF application in South Dakota.

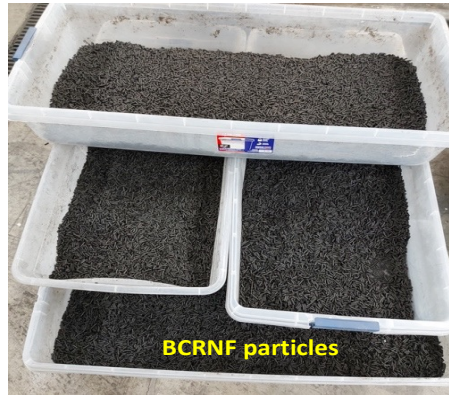
Results:

Objective 1: Optimize BCRNF technology for corn growth through greenhouse trials.

We had developed 4 generations of BCCRNF samples based on different compositions of fertilizer particles and coating materials. The results indicated that the 4th generation BCRNF samples coated by PLA solution performed well in corn growth in both greenhouse and field trials. The 4th generation of BCRNF was synthesized by combining urea with biochar and different biosolids (e.g., compost, manure, etc.) and then coated by PLA solution using a pilot scale BCRNF production line (Figure 1a) at a capacity of 20 lbs/hr. About 500 lbs of the 4th generation BCRNF samples (Figure 1b) was produced for the corn greenhouse and field trials during the reporting period. To examine the effects of BCRNF on spring wheat growth, a greenhouse trial (Figure 2) integrating with the classes of BOT 327/L: Plant Physiology, was carried out on March 15, 2023. A greenhouse trial (Figure 3) was started to investigate the responses of corn growth on different BCRNF treatments on May 12, 2023.

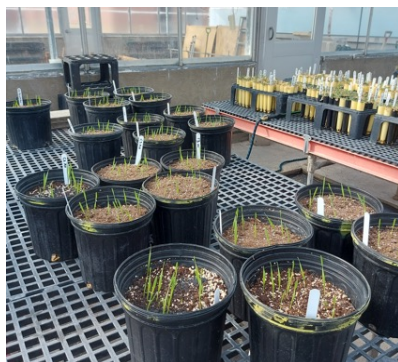


(a)



(b)

Figure 1. (a) the graduate students were producing BCRNF samples using the pilot scale production line established in our labs. (b) About 500 lbs of BCRNF samples produced for the ongoing greenhouse and field trials.



(a)



(b)

Figure 2. (a) wheat germination in the pots with different BCRNF treatments. (b) undergraduate students checked the wheat growth in the greenhouse trials.



(a)



(b)

Figure 3. The greenhouse trial of corn growth under different BCRNF treatments was started on May 12, 2023.

Objective 2: Evaluate BCRNF effectiveness on corn productivity through field trials.

Two corn field trials were conducted to investigate the responses of corn productivity on different BCRNF treatments under tillage and non-tillage conditions in two research farms at Beresford and Brookings SD, respectively. A total of 16 different fertilization treatments were designed and carried out with 4 replications for each treatment for each field trial site. The implementation of field trial at Brookings site is shown as Figure 4. The implementation of field trial at Beresford site is shown as Figure 5. Hundreds of soil and plant samples were collected, stored, and/or processed for the analyses of N release, N sources, total N, soil microbiology, biomass, etc. in the field trials.



(a)



(b)

Figure 4. The corn field trial was carried out for the tillage field at Brookings site.



(a)



(b)

Figure 5. The corn field trial was carried out for the non-tillage field at Beresford site.

Objective 3: Evaluate economic feasibility of BCRNF application in South Dakota.

Started to collect references and data for economic evaluation of BCRNF application in South Dakota, but not much work has been done on this objective 3.

Project budget and expenditures to date

We have spent the research funding for purchases of equipment, tools, and supplies along with the project timeline, but not all expenditures are reflected on the table 1, in which we received the latest updated from the grants and contracts office at SDSU. For example, we sent soil samples to commercial labs for measuring N concentration in water and soil, but those contractual expenses (\$5,600) were not shown in the table 1. The salaries paid for a new PhD student, Mithlesh, who started to work on the project on May 22, 2023, were not shown in the table yet.

Table 1 Budget and Expenditures to 6/30/2023

Items	Financial System budget on 1/1/2023	Cumulative Expenses Through 6/30/2023.	%
Salaries	\$56,361	\$56,361	100
Benefits	\$7,953	\$7,953	100
Travel	\$3,000	\$3,000	100
Contractual	\$18,000	\$18,000	100
Supplies	\$12,500	\$6,709	46
Tuition or Tuition Remission	\$9,205	\$9,205	100
Capital Equipment	\$8,000	(\$9,249)	(15.6)
Total	\$115,519	\$99,561	86

Brief Summary:

- 1) Utilized the pilot scale BCRNF production line established in our labs to produce 500 lbs of BCRNF samples for the second-year greenhouse and field trials.
- 2) A greenhouse trial was carried out to investigate the responses of corn growth on the 4th generation of BCRNF.
- 3) Two corn field trials are being conducted to examine the responses of corn productivity on the BCRNF samples in cases of till and non-tillage conditions at two sites: southeast farm (Beresford, SD) and research farm (Brooking, SD) respectively.
- 4) Investigated the responses of spring wheat yield on BCRNF in greenhouse trials.

Outcomes and Impacts:

- 1) Integrated precision fertilization research and college education programs for dissemination of the new knowledge and BCRNF technologies. More than 35 undergraduate and 7 graduate students participated in the BCRNF project.
- 2) Recruited two new PhD students to participate in the BCRNF research.
- 3) One manuscript was submitted to the journal of Agriculture Research for publication but still under reviewing. A total of 12 oral/poster presentations will be presented in the national and international conferences (ASABE 2023 AIM and S-1075 USDA multi-state project annual meeting on July 9 – 14, 2023).

Changes in project or personnel,

There is no change in research objectives/tasks or personnel in the project.

Products (publications, presentation, disclosures/patents),**1) Peer-reviewed journal papers**

- i. Robiul Islam Rubel, Lin Wei*, Yajun Wu, Surbhi Gupta, Salman Alanazi, Sikander Ameer, Abdus Sobhan, Augustina Osabutey, Xufei Yang. Developed bio-based controlled-release nitrogen fertilizer to improve corn yield via greenhouse trials. Submitted to the Journal of Agriculture Research on May 10, 2023. Under reviewing.

2) Posters/presentations

- i. Mithlesh and Lin Wei*. Overview the response of soil properties and microbial communities to Biochar based control release fertilizers. USDA NIFA S1075 multi-state research project annual meeting on July 13 – 14, 2023. Omaha, Nebraska.
- ii. Lin Wei*. Development and Application of Smart Fertilizers for Shifting Crop Management from 3D to 4D Model in Precision Agriculture. Paper #: 2301101. ASABE annual meeting, July 9 – 12, 2023. Omaha, Nebraska.
- iii. Lin Wei*. Systematical Modeling of Crop Growth. Paper #: 2301100. ASABE annual meeting, July 9 – 12, 2023. Omaha, Nebraska.
- iv. Robiul Islam Rubel, Lin Wei*, Yajun Wu*, Abdulkarim Aldekhail, Anne C. M. Cidreira. Effect of biochar based controlled-release nitrogen fertilizer on wheat growth. USDA NIFA S1075 multi-state research project annual meeting on July 13 – 14, 2023. Omaha, Nebraska.

- v. S. Alanazi, L. Wei*, R. I. Rubel, K. Muthukumarappan, A. Aldekhail. Effects of water uniformity of a drip irrigation system on crop productivity. Paper #: 230000. ASABE annual meeting, July 9 – 12, 2023. Omaha, Nebraska.
- vi. Robiul Islam Rubel, Lin Wei*, Salman Alanazi, Abdulkarim Aldekhail. Effects of coating contents on nitrogen lost through leaching from biochar based controlled release fertilizer particles. Paper #: 230000. ASABE annual meeting, July 9 – 12, 2023. Omaha, Nebraska.
- vii. Abdulkarim Aldekhail, Lin Wei*, Robiul Islam Rubel, Kasiviswanathan Muthukumarappan. Development Biochar-based Control Release Nitrogen Fertilizers Coated by Polypropylene. Paper #: 230000. ASABE annual meeting, July 9 – 12, 2023. Omaha, Nebraska.
- viii. Abdulkarim Aldekhail, Lin Wei*, Robiul Islam Rubel, Kasiviswanathan Muthukumarappan. Biochar Based Controlled-Release Nitrogen Fertilizer as An Enhancer. USDA NIFA S1075 multi-state research project annual meeting on July 13 – 14, 2023. Omaha, Nebraska.
- ix. Anne Carolyne Mendonca Cidreira, Lin Wei*, Robiul Islam Rubel. Develop an ethyl cellulose coating material for fabrication of biochar-based controlled release nitrogen fertilizers. USDA NIFA S1075 multi-state research project annual meeting on July 13 – 14, 2023. Omaha, Nebraska.
- x. Anne Carolyne Mendonca Cidreira, Lin Wei*, Robiul Islam Rubel. Modeling of N release from coated urea fertilizers in soil environments. Paper #: 230000. ASABE annual meeting, July 9 – 12, 2023. Omaha, Nebraska.