Whole System Approach to Integrated Crop/Livestock Production to Enhance Soil Health and Profitability of Cropping and Livestock Systems in the Northern Great Plains

Progress report for LNC18-412

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Project Information

Summary:
The Northern Great Plains (NGPs) is an area where cover crop establishment can be risky due to short growing seasons and/or limited water. With the short growing season also comes increased land-use competition between crop and livestock enterprises. This study aims to study cover crop and livestock integration in a comprehensive manner so that thorough economic, soil health, and livestock performance variables can be measured during the process of adopting cover crop grazing. The project enlists experts in each topic area to ensure the project is conducted appropriately for each discipline represented. The project will accelerate the outreach of cover crop and livestock integration through the use of cafe talks, workshops, with a farmer-focus. Demonstrations are simultaneously occurring on-farm to test the adoptability of cover crop grazing on a commercial scale.

Thus far the project is proceeding to accomplish the original scope, however it will take more time than initially believed. The Covid-19 pandemic greatly reduced the ability to conduct outreach in 2020. The plan is to proceed with tours and workshops in 2021. The research objectives will also still be achieved with the new timeline.

Project Objectives:

1). Evaluate an integrated crop/livestock management strategy of backgrounding weaned calves under a double or relay-cropping system by grazing cover crop and crop residues after cash crop harvest.
2). Evaluate the effect of cover crops and grazing livestock on soil health under a no-till system.
3). Conduct an economic analysis to evaluate the financial impacts of an integrated
Introduction:

Traditional backgrounding systems in the NGPs involve feeding harvested forages, co-products, and grains in a drylot setting for two to six months post weaning. Grazing cover crops is key for developing a low-cost system for wintering cattle by eliminating harvest and lowering yardage costs. Incorporating cover crops into existing crop rotations in the NGPs will improve the quality and quantity of available biomass for weaned calves. Undertaking this study will provide new information regarding the profitability of backgrounding calves in the NGPs and provide farmers with an opportunity to maximize profits and reduce the cost of their operations. Recent cow-calf return estimates from USDA's Economic Research Service showed high costs of production across the nation coupled with lower calf revenue. If these trends hold true, a number of farm families across the NGPs will be negatively affected. The key to sustainability in cow/calf operations will be to increase revenue and decrease expenses. Grazing cover crops in double or relay cropping systems is an efficient method for farmers to decrease feed costs when backgrounding weaned calves in the NGPs, which may lead to an increase in farmers’ net revenue (McCartney et al., 2008; Kumar et al., 2012).

The benefits of cover crops in improving cropping systems and agricultural sustainability are well documented and include increased soil organic matter and nitrogen, reduced soil erosion, increased nutrient cycling, improved soil structural properties, weed suppression, increased soil productivity and increased cash crops yield (Sarrantonio and Gallandt, 2003; Ghosh et al., 2006; Wortman et al., 2012; Blanco-Canqui et al., 2012; Bich, 2013). Despite the numerous benefits of incorporating cover crops into the cropping systems, adoption remains limited due largely to 1) the time commitment to plant cover crops at critical times of the growing season, 2) farmers’ concerns on the lack of short-term economic returns, but also 3) a lack of research studies on the benefits of cover crops in a cover crop/livestock integrated system in North Dakota. This study will address the third item, which in turn can help to address the second one. One short-term economic benefit is integrating livestock into the cropping system and increasing forage biomass at a time when forages in native pastures have declined in quality (Liebig et al., 2015). Additionally, cash crops will benefit from added nutrients from livestock manure which can also help improve soil health. Loss of soil organic carbon (SOC) from intensive annual cropping can negatively impact soil health and increase farmers’ reliance on commercial inorganic fertilizers to sustain crop productivity. Utilizing cover crops could benefit the cash cropping system by increasing soil organic matter, biological activity, greater retention and recycling of nutrients, and reduced erosion. Incorporation of cover crops like winter rye, clover, brassicas, etc. can also help reduce the need for synthetic fertilizer use over time.

Due to the short growing season in the NGPs, an interseeding or double cropping approach can be a workable option for incorporating cover crops into the existing cropping systems (Moore and Karlen, 2013). Seeding rye prior to soybeans has become a more acceptable approach recently, partly due to research conducted at NDSU and other universities in the Great Plains (De Bruin et al., 2005; Kaspar and Singer 2007). Primary goals for that system generally include management of glyphosate-resistant weeds and preventing soil erosion during the soybean crop years. The adoption of that system by area farmers has opened the door to interest in similar systems for corn production, including interseeding rye, hairy vetch,
brassicas, and others. However, small grain production still represents the biggest opportunity to utilize cover crops in the NGPs. Both research results (Cicek et al., 2014; Samarappuli et al., 2014; Jones et al., 2015) and anecdotal evidence (i.e. less soil erosion reported by farmers with living cover crops) support the use of fall cover crops following spring wheat and are demonstrated options that can positively affect subsequent crops and soil health. Many of these options would also further support integrated crop/livestock systems.

Moisture competition can be an issue for some cash and cover crop combinations. Since double cropping is perhaps the only option to use cover crops in corn in the NGP, crop competition must be considered. Cover crops in this study will be seeded mid-season in the corn to balance the ability to grow sufficient biomass for grazing while not competing with corn at the early growth stages. Grazing in a corn/CC system has been understudied in North Dakota, but unpublished research from the NDSU-Central Grasslands Research Extension Center indicate that cover crops seeded into corn were producing yields of ~1000 lb/a (rapeseed, winter peas, triticale, oats). These values could be increased by using high biomass crops like hairy vetch and winter rye which also grow very late into the fall. Using a planter, rather than broadcasting seed, is also likely to also increase establishment. Research at the NDSU-Carrington Research Extension Center has measured up to 2 tons/a of corn residue after corn harvest. Assuming a conservative 25% utilization of the corn, and 13.75 lb/day DM intake per cow, the area used for this study should be sufficient in size.

Growing cover crops for fall grazing is viewed as a challenge in the NGP, since dry conditions and few frost free days limit cover crop species options and planting window, which can limit the amount of forage available for grazing in the fall. The perception of cattle-related compaction is also an obstacle for incorporating grazing on cropland. Through on-farm demonstration and farmer-driven implementation, this project will provide evidence that with proper management, crop production and fall grazing can be achieved in a synergistic way, on the same field, during the same growing season, with positive results to both components of the system. This research topic was initiated based on producer feedback from the Carrington Research Extension Center advisory board. Through inquiry, we found that both crop and livestock producers are interested in this synergy, particularly if economic and/or soil health benefits could be demonstrated. This systems approach is consistent with SARE’s mission and core ideologies, as research is still lacking on utilizing double or relay-cropping strategies to add lower-cost weight on weaned calves in the NGPs.

References
Journal. 101, 1286-1296.


Cooperators

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Research

Hypothesis:

Integrating animal agriculture into cropping systems will have varied impacts on an operation with measurable differences in a) soil biological activity, b) economic efficiency, and c) animal performance.

Materials and methods:

A cover crop/grazing study, under a no-till cropping system, will begin in the 2019 growing season and continue through the 2020 season. The objectives of the crop rotation study include 1) determine the impacts of cover crops and grazing treatment combinations on the current and subsequent rotation crop; 2) measure cover crop biomass production on grazed and no-grazed treatments; 3) measure soil health indicators on grazed and non-grazed treatments, and between treatments with and without cover crops. The trial will consist of a crop rotation experiment that includes combinations of cash crops, cover crops, and grazing treatments. The main plot (490 ft x 300 ft) will be cash crop, which will be either corn or wheat, and replicated three times across the experimental area. Each main plot will be split into three subplots. The subplots will consist of a positive control (45 ft x 300 ft), negative control (45 ft x 300 ft), and the grazing treatment (400 ft x 300 ft). The positive control will be a cash crop paired with cover crops but no grazing, representing maximum cover crop biomass production. The negative control will be a cash crop with no cover crop or grazing. The grazing treatment will consist of fall grazing of cash crop residues and cover crops. Table 1 shows the cover cropping system being evaluated with each cash crop.

Table 1. Description of stage of planting and cover crop mixes following each cash crop.

<table>
<thead>
<tr>
<th>Cash Crop</th>
<th>Cover Crop</th>
<th>Time of Cover Crop Planting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>Peas/Radish/Turnip</td>
<td>After wheat harvest</td>
</tr>
<tr>
<td>Corn</td>
<td>Rye/Turnip/Radish/Barley</td>
<td>Corn V5-V6</td>
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</tbody>
</table>

In each year of the study cash crop yield and quality will be measured. Cover crop
yield will also be measured in plots seeded to cover crops. Each subplot will be split in four equal areas (1100 sq ft each) to measure yield and other agronomic parameters on equal areas. The trial will be established as a randomized complete block with a split-plot arrangement.

After cash crop harvest, spring-born steer calves will be allowed to graze the crop residues and cover crops in late fall. The grazing period will be determined by availability of sufficient biomass to maintain positive weight gains. Prior to grazing, available biomass will be determined in each plot by clipping all the forage within a 1 m$^2$ quadrat. Forty-five spring-born steer calves will be stratified by body weight and assigned to the following treatments: 1) wheat plot grazing, 2) corn plot grazing, 3) drylot backgrounding. Calves will be backgrounded over a period of 84 days. There will be 3 replicates (plots or pens) per treatment with 5 calves assigned to each replicate. Calves in the drylot will be fed a high forage diet for the duration of the study. Because of the limited area for grazing, steers from treatments 1 and 2 will be transferred to the drylot and will receive same diet as treatment 3 once the grazing period is ended. Calves will be weighed on days 0, 28, 56 and 84.

All the calves will be subjected to ultrasound measurement to estimate marbling score, ribeye area and fat depth at the beginning and the end of the study. Estimation of animal muscle and fat composition change between the start and end of the grazing period will be determined with an Aloka SSD-550V ultrasound machine equipped with a 3.5 MHz-17 cm transducer. Estimates will include longissimus-dorsi muscle area, fat depth, and percent intramuscular fat for marbling score determination. Composite forage samples will be collected from each plot and analyzed for chemical composition – dry matter (DM), crude protein, ash, neutral detergent fiber, acid detergent fiber, acid detergent lignin, cellulose, hemicellulose, and non-structural carbohydrates. Data generated will be subjected to analysis of variance using the Proc Mixed procedure of SAS (Version 9.4) in a randomized complete block design with a split-plot arrangement, with probability value (p-value) of 0.05.

Soil health will be assessed on soil samples (0-6 inches) collected before and after the implementation of the treatments, and it will based on the determination of biological, chemical and physical soil attributes that are more likely to be affected by the treatments. Biological indicators to be evaluated include SOM, and the physical fraction of soil carbon – particulate organic matter carbon (POM). Soil OM will be determined by loss on ignition at 360°C, and POM of size ranging from 53-2000 µm by the procedure of Sollins et al. (1999). POM will consist of permanganate oxidizable carbon (POC), from short-term soil incubation (Nelson and Sommers 1996). Phospholipids fatty acid (PLFA) analysis will be conducted as it provides a snapshot representation of living soil microbial biomass, community structure and abundance as affected by cover crops and livestock activity. Chemical indicators will consist of macro nutrients such as soil nitrate nitrogen (N) and phosphates (P), micronutrients (Zn, Fe, and Mn), soil pH, soil electrical conductivity, and soil cation exchange capacity.

A Magnum series Case-IH tractor with a dynamometer will be used to pull a no-till seeder across the experimental plots each spring. The tractor will be equipped with an AFS Pro 700 monitor and RTK-GPS to collect and map tractor performance data including fuel consumption, engine load, and fuel efficiency. The tractor speed and seeding depth will be held constant throughout all plots. Fuel efficiency (acres/gallon) will be used to indicate soil strength and compaction (physical properties). Data from the AFS Pro 700 will be exported to ArcGIS software for data point analysis and to create a soil compaction map of the experimental units.
An economic analysis of interseeding cover crops into 3-crop rotation will be carried out to evaluate their effects on the cash crops. Additionally, an economic analysis of backgrounding calves on the cover crops as well as in the drylot will be done to compare the costs and profitability of each type of backgrounding to let us know if it is financially feasible to background the calves on cover crops versus a traditional drylot situation. In order to achieve this, records of all direct costs for the cover crop grazing as well as for the feedlot backgrounding will be recorded. The beginning and ending weights of the calves will be used to put a per pound value on them so as to measure how much income would come from each backgrounding method. List of records to be kept include costs for drylot, cost of production of feeds, or costs of feeds purchased, custom hire for any processing of feeds such as hay grinding. Costs for cash and cover crops – cost of seed, cost of fertilizer, cost of chemicals, custom cost to plant, cost of fencing, etc. Cost to be recorded for overheads for both enterprises are fuel, land cost, building depreciation, machinery depreciation, utilities, vet, supplies, marketing, etc. Labor will be recorded for each enterprise and specifically charged. Incomes – calf weights at weaning and calf weights at end of study. Prices will be recorded at each of those points to put a value on the calves. Any death loss will be recorded as well. From the economic analysis, we plan to provide information and a guide that farmers can use to integrate cover crops into their operations. This guide will help crop farmers estimate how much they can charge a livestock farmer neighbor to graze the field. In order to arrive at a fair estimate, we will factor in an adjustment for manure credit for grazing livestock and compaction if needed.

Research results and discussion:

In the fall of 2019 there was a large snow storm in October that buried the corn research plots. This prevented any grazing from occurring as much of the snow remained until spring. The small grains plots were still able to be grazed that year. All plots were successfully established and grazed in 2020. The cover crop growth was greater in 2019. A drought in 2020 reduced cover crop growth. This limited the grazing days in the small grains system. Due to availability of both cover crop and corn residue, there was much more opportunity for grazing in the corn system even with the dry conditions. In 2020 we switched the farmer cooperators from aerial broadcast to ground-based broadcast seeding. In 2019 the it was difficult to arrange aerial applications due to limited availability of aerial seeding platforms, and competition with time demands for custom aerial spraying. The ground applications improved overall satisfaction with the broadcast seeding practice among farmers and researchers. One grower was not able to seed in 2020 and but will make an attempt in the summer of 2021. Many of the analysis for this trial are ongoing.

Participation Summary

3 Farmers participating in research

Education

Educational approach:

There are two primary forms of education associated with the project; on-farm demonstration and cafe talks. There are three farmer cooperators associated with this project that will be testing on-farm cover crops for grazing, utilizing commercial cover crop seed spreaders (aerial or ground-based). Farm walks are included in the
fall in corn fields that have had cover crops spread. The other component of education is the cafe talk aspect that occurs during the winter months. This included some virtual meetings in the second year. These talks encourage one-on-one interactions and let the growers dictate the topic coverage and facilitates grower-to-grower interaction.

Project Activities

   Cover crops and grazing lunch and learn
   New Rockford Cafe Talk
   Cover Crops Grazing Tour

Educational & Outreach Activities

   12 Consultations
   2 Curricula, factsheets or educational tools
   2 Published press articles, newsletters
   3 Webinars / talks / presentations
   1 Workshop field days
   2 Other educational activities: Cafe-style meetings with producers

PARTICIPATION SUMMARY:

   62 Farmers
   16 Ag professionals participated

Education/outreach description:

   With Covid-19 the 2020 outreach activities were minimal. However we were able to do a two additional virtual format presentations with mainly-farmer attendance.

Learning Outcomes

   Key areas taught:

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