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WORLD CONGRESS 6 on CONSERVATION AGRICULTURE

Session 1: Conservation Agriculture: Building Sustainability

ORAL ABSTRACTS

Thinking about your Thinking

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Background:
Rethink how you think about increasing food production in an intensive but sustainable fashion. Before you try to solve food production problems and get all tied up in one area of expertise go back to basics and evaluate all of the items that determine yield and score the system.

Results:
Results can come quickly once all items predicting yield outcomes are first measured. UYMI has

developed a simple yet very effective method of thinking about the solutions.

The aforementioned items of yield prediction are utilized as a form of "performance review" on the farm production system. Each item is scored individually through an intense interview with the producer. Although many producers are progressing, many still score in the 60's when it comes to increasing overall yields.
The chart below is a good example of a farm personality review. And what can be done to increase overall score and therefore production. High scores almost always predict final yield and therfore the simple calculation, although somewhat subjective, generally predicts the final outcome.
Results: disappointing results when applying new technologies often come from a combination of these factors and may mask the true potential of the actual new technology. (I.e.) If we test new genetics on production systems that score low, the benefit of the new genetics does not reflect its real potential to growers who are often disappointed in what could be great technology.

Application and Implications for Conservation Agriculture:
The basic concept of correlating the many factors that impact yield has not been well understood or modeled. Data mining and artificial intelligence will create models that make this process far more accurate.
Organizations and individuals who research new approaches and or technologies need to use a universal scoring system so that we have a universal language that in one score denotes the conditions with which the results were obtained. Specific new technologies that will create a new way in how we think about sustainable agriculture.

Farm Personality Review				
Date: ________	Grower: ________			Crop Type: Canola
Factor		Initial Score	Final Score	Recommendations
Seed Bed Preparation	Crop rotation 6 Residue 8 Herbicide residue 4 Seed bed 9.5	69%	84%	Switch to clearfield variety in current year Consider stacking issue long term Re evaluate long term rotations
Nutrition TY-40	N-85; P-20; K-0; S-18 Soil P testing 12 ppm K levels critical as base saturation is 2% Target yield is higher than planned N app	60%	85%	Add additional 30 lbs N as top dress Consider alpine phos 4 gallons/acre Add 15 lbs K Soil build phos to 20 ppm
Seed Quality	TKW 2.6 gms	75%	100%	Find larger seed lot min 4 gms
Seed Depth	Speed 5.2 mph Parrel link	60 %	95 %	Reduce speed to 4.2
Seeding Date	Soil temperature considerations 3rd week may antisipated	60 %	80 %	Mitigate cold soil with seed place phos Move seed date up 1 week
Pest Control	Volunteer rr canola Cleavers Sclerotinia risk	70 %	95 %	Consider contans long term sclerotinia control 2 app system for glyphosate, use juice for y drag Use amitrol preburn for vol rr
Weather				
	Total Score	66 %	90 %	
	Potential Improvement			

How will the following technologies change the way we think?

How will they impact the final score and therefore sustainable intensification will be discussed.

1. Artificial intelligence and research
2. Data mining
3. 3-D printing
4. Crowd Sourcing, hero x and x prize
5. Sensors
6. Robot

Research Trials conducted are as follows:
Ultimate Yield Research for 2012 and 2013
2013

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The Importance of Providing Landowners with the Full Spectrum of Information and Resources on Conservation Agriculture

Breana Behrens, Resources First Foundation

Private land managers are the key stewards of the natural resources that we all depend on for food, fiber and energy. They are also becoming increasingly aware of the role they play in conserving natural resources for the overall health of our environment. Many are implementing conservation agriculture to bolster economic and environmental successes on their land.

However, to meet ever increasing global demands more land managers must be at the forefront in implementing innovative conservation agricultural techniques that maximize yield, while minimizing resource inputs and impacts. Unfortunately, conservation agriculture is not a one-sized fits all approach to land management. Land types, uses and users vary, which makes it essential that managers have access to the full range of options available to them in order to determine which tools, or combination of tools, are the best for them and their land.

Knowing that each farmer is as unique as their land, Resources First Foundation (RFF) has created a database of information and resources for private land managers. The website contains a wide range of informational articles on best practices for agricultural land, as well as federal, state, nonprofit and private sector programs, and local professionals can help implement the practices.

To reach more farmers and encourage their involvement in conservation agriculture RFF's platform is comprehensive, reliable, and void of political or idealistic pressures. The websites are designed like an open library, so that farmers can freely browse through introductory and professional articles on conservation tools, such as cover crops, no-till farming, and water saving irrigation techniques. There is also information on what to do if there are important ecological features on the land, such as wetlands, endangered or threatened species, or rare habitat.

RFF focuses on voluntary and incentive based programs for implementing conservation agriculture. These programs are instrumental in building flexibility and monetary support for implementing conservation agriculture practices on land. It is also important to provide localized contact information for professionals and organizations. Through an interactive map, RFF pinpoints soil and water conservation districts, cooperative extensions, land trusts and other conservation professionals, ecologists, biologists and other land consultants, as well as attorneys that specialize in agricultural law, estate planning and tax issues.

The Conservation Tax Center specifically focuses on federal and state conservation tax incentives available to landowners, such as conservation easements and current use property appraisals. The CTC also hosts estate planning information to ensure that farms can be successfully passed to future generations without facing the threat of being sold, divided, and developed due to transfer taxes and lack of a sufficient estate plan. When adopting agricultural conservation, the focus is not only on managing land well today, but ensuring that there is a plan for keeping working landscapes ecologically and economically sound in the future.

It is essential that those who are stewarding and cultivating our natural resources have the ability to keep doing so for generations to come. Conservation agriculture provides them with the tools to do so, but must be conveyed in a way that allows managers to explore their options, enroll in the right programs and implement the best practices for their land.

Adoption Trends of Environmentally Sustainable Practices on Canadian Farms

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Background

Understanding adoption trends of environmentally sustainable practices on farms is important for a variety of stakeholders ranging from producer groups, research/technology development organizations, and governments in developing/evaluating programs and policies. In Canada, the Census of Agriculture (CoA) and Farm Environmental Management Survey (FEMS) are two primary farm management data sources used for this purpose. For example, integrated spatial analysis of farm management and land resource data has been used to generate agri-environmental indicators at the national scale. This presentation focuses on some key adoption trends as determined through analysis of FEMS. There is also some discussion about how future farm management surveys may be changed to facilitate a commodity or sector based approach to understanding adoption.

Key Results

In Canada, analysis of CoA has shown dramatic adoption of conservation tillage and reduced fallow since 1991. More recently, using global positioning systems (GPS) as a tracking or guidance system to eliminate overlaps or misses in field operations has also increased dramatically. Progress has been made in nutrient management, particularly as it relates to conservation tillage systems that also optimize application of commercial fertilizer. However, managing nutrients from manure sources continue to present challenges. Other practices with some adoption but room for improvement involve grazing and riparian management, and the use of cover crops.

Experimental Approach

FEMS is a joint initiative of Statistics Canada (StatsCan) and Agriculture and Agri-Food Canada (AAFC) in collaboration with various provincial government agriculture departments. However, cost of the survey is borne almost entirely by AAFC. Three surveys have been undertaken in the past: 2001, 2006, and 2011. FEMS began as a single questionnaire; but in 2006 changed to 2 modules, crop and livestock, with some common questions maintained in both. The same approach was used in 2011, but some questions were changed or restructured to improve survey efficiency and information quality.

FEMS has utilized a stratified sampling approach designed to represent Canada's 10 provinces, 12 ecoregions, and the primary crop and livestock types across the country. This is achieved by selecting candidate farms from the StatsCan Farm Registry. However, certain types of farms are excluded from the survey, such as very small, very large, farms from northern territories, greenhouse, sod, and nursery operations, and institutional farms. In the end, about 6% of farms are surveyed, and a weighting system is used to scale up results to represent all farms in Canada.

Further changes are envisioned for future surveys, such as moving to a more defined sector/commodity based approach. The rationale for this approach is a growing need for specific sectors or commodities to assess sustainability of their products and on farm processes to assure future market access. This will likely require conducting smaller surveys more often and engaging greater participation of industry and producer groups in survey design, analysis, and reporting.

Results and Discussion

Percent of Farms or Acres Implementing Various Practices (Source: FEMS, unless noted otherwise)

Selected Management Practices	Denominator [1]	Year	
		2011	2006
No Till or Reduced Till (Source: CoA)	annual crop acres	81.0	72.0
Fallow land (Source: CoA)	annual crop acres	5.5	8.8
Using GPS for tracking or guidance	farms that grew crops	44.2	22.7
Soil test a typical field every year	farms that applied commercial fertilizer	20.2	17.8
Fertilizer placed with seed, side banded at seeding time, or applied post seeding	farms that applied fertilizer to annual crops	70.9	74.0
Reduced fertilizer rate on manured lands	farms that applied both fertilizer and manure to the same land	82.5	82.7
Solid manure predominantly applied in spring and/or summer	farms applying solid manure	38.4	60.0
Liquid manure predominantly applied in spring and/or summer	farms applying liquid manure	45.1	61.7
Solid manure incorporated within 2 days	farms incorporating solid manure [2]	57.0	58.4
Liquid manure direct injected	farms applying liquid manure	7.1	10.9
Rotational grazing	farms with grazing livestock	69.6	72.0
Average height (inches) of grass after final grazing period before winter	farms grazing tame and/or native pasture	1.70	3.63
Restricting livestock access to surface water	farms with grazing livestock adjacent to surface water	33.2	33.3
Grazing swaths or windrowed crops in winter	farms with grazing livestock	7.2	11.0
Cover, companion, or green manure crops	farms with significant cropland (ie. crop & mixed farms)	21.0	29.1

[1] The denominator is the total that the percent value is based on.

[2] The % of farms incorporating solid manure within 2 days is actually lower, if one included non-incorporated manure applied to annual cropland in the denominator. However, it was not possible to distinguish between annual and perennial cropland receiving manure, and deemed inappropriate to include non-incorporated manure since incorporation is not feasible on perennial cropland.

The oral presentation will provide some more detailed results showing regional differences, as well as some likely reasons for the trends observed.

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REACHing Out: An Innovative Participatory Approach to Conservation Integration in Agriculture

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There is increasing societal awareness of natural resource concerns in both agricultural systems and the downstream receiving water bodies. These concerns are reflected in current policy discussions at both Federal and State levels, where there is a desire for 1) increased accountability with regard to agriculture's impact on the environment, and 2) documentation of how well on-the-ground programs and conservation practices are doing to improve our natural resources. REACH (Research and Education to Advance Conservation and Habitat) is a program within Mississippi that is producer led that will address these two points. REACH provides landowners within Mississippi coordination and support for documenting the benefits of conservation efforts to natural resources and importantly to agriculture on specific farms throughout the state. REACH then utilizes those outcomes and demonstrates the successes of conservation and agriculture integration. The successes are documented using innovative outreach, but grounded in defensible science.

The goal of REACH was to create a network of cooperative farms in Mississippi, with variable agricultural systems, degrees of conservation initiatives, and ecosystem monitoring to illustrate the success of conservation practice implementation. Since the program is producer-driven, the goals were focused on reaching producers. REACH was established in May 2012, and the goals outlined were to enroll ten REACH producers by November 2013, and by November 2016 have enrolled 20,000 hectares. In the first year of existence, REACH worked with and enrolled 41 farms, encompassing over 51,000 hectares. These farms provide producers, conservationists, educators and policymakers with key information to better implement and advocate management practices orientated around various local and regional objectives (e.g., targeted nutrient reductions, agricultural production system improvements, habitat restoration).

REACH continues to grow with support from MSU as well as other partner agencies. While government assistance is provided by the US Department of Agriculture Natural Resource Conservation Service (USDA-NRCS) to implement BMP, many farmers are unaware of many of the BMP that exist or do not know how to apply for government cost-share programs that they are qualified to participate in. REACH closes the loop between government and producers, helping them to adopt conservation practices that enhance their production, and in turn, providing the government with scientifically-defensible data that evaluates the BMP for which they provide hundreds of millions of dollars in cost-share. Additionally, REACH utilizes the success stories of farmers that have adopted these practices to help promote conservation of our natural resources. This promotion technique has helped garner producer interest and support for government programs, despite historical resistance to government involvement in farming practices in the Mississippi Delta. At the same time, REACH helps promote the success of marrying conservation and agriculture, changing the public view of producers from polluters of our nation's waters to protectors of our nation's most precious resources – food, fiber, and water.

REACH is unique in several ways. First, with traditional BMP implementation, producers must sacrifice production land to accommodate the BMP; this puts agriculture at odds with conservation. REACH shows that these are not competing systems, and BMP can fit seamlessly into the agriculture landscape. Second, REACH is producer-driven, with REACH providing assistance that furthers the producer's conservation goals while aiming to enhance farm productivity and profitability. Additionally, REACH provides scientifically-defensible data of BMP efficacy on actual production fields. Ultimately, these factors culminate in REACH providing sound justification for government investment in conservation.

REACH has had numerous lessons learned in its short existence. First and foremost, our success comes from involving front-line stakeholders in championing the cause. The success of REACH is due ultimately to our landowners and producers. It is their message that is important – not the program's. The program is merely a conduit to disseminate the success of these stakeholders and their stewardship. We have also been fortunate to have charismatic leaders in the community advocate for REACH. Second, government agencies (USDA-NRCS and MDEQ) have recognized the need for documenting successes of investment. Documenting successes is not only good to show improvement and progress, but also validates the investment, and helps these government agencies justify the continuation of their related programs to budget committees and taxpayers. Documentation also provides critical information for regulatory instruments that can be adaptively managed in light of new information.

Several approaches can be credited with REACH's success. The success of REACH lies in the hands of our producers. The willingness and want from the landowners and stakeholders of Mississippi to showcase their successes of conservation integration and profitable production agriculture drives the program – they want their peers to see that it is possible to have both conservation and profitability. Additionally, the desire of our landowners and stakeholders to constantly want to improve their operations and make their operations more efficient translates into adoption of a conservation mindset. REACH focuses on one-on-one interaction. It is a personalized, producer-driven program. REACH is also a partnership, not only with producers, but also with a network of collaborators. REACH was born on a foundation of collaboration and it has continued that by expanding its roster of partners to 29 entities including state and federal government agencies, private industries, and NGOs.

Like any new program, REACH has had some challenges. While we haven't seen many limits to the enthusiasm with which the program has been embraced by stakeholders, we have experienced the standard challenge for any program, limitations on resources. As the program matures and proliferates, REACH must maintain and grow its resource-base for program productivity and longevity. REACH has also had to overcome a hurdle of skepticism from stakeholders. Often when articulating to a stakeholder what REACH is designed to do – which simply is help them in whatever they need help with as it relates to conservation – the response is often that the program sounds too good to be true. To combat this mindset, we use our REACH producers to sell the program. Instead of REACH program staff convincing the producer of the merits of REACH, we share contact information of consenting REACH producers with the prospective individual. Lastly, there are times when we may not be able to provide the right answers. Since REACH is a personalized program, there are times when a new problem occurs, and program staff lack the experience and expertise to assist a producer immediately. This is where those collaborative relationships are crucial. REACH relies on these partnerships to fill the knowledge gap and get producers the necessary answers to help them further their goals. The REACH website (www.reach.msstate.edu) provides a wealth of materials to help promote conservation in agricultural landscapes.

Sustainable Intensification and Conservation Agriculture

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Keywords: no-till farming, ecosystem services, resilience, paradigm, productivity

What is sustainable intensification?

The term sustainable intensification has become popular in recent years and while its definition can vary, it can be considered in both a narrow and a broader sense. The narrow definition applies to the pursuit of the dual goals of higher biological yields (output) and productivity (efficiency of use of production inputs) with fewer negative consequences on the environment (such as in situ land degradation and negative externalities) while building resilience (stability of performance and ability to recover from biotic and abiotic shocks), natural capital (biodiversity and soil health) and at the same time enhancing the flow of environmental services (such as water and water cycle, nutrients and nutrient cycles, control of soil erosion, pollination services) (FAO, 2011; Foresight, 2011). This 'holistic' approach integrated production systems development and landscape management in rainfed and irrigated landscapes.

In the broader context, sustainable intensification encompasses the minimization of food wastage, as well as human and economic dimensions of socio-cultural aspirations, organizations and social equity and economic growth. It also implies improving the capacities of people and their institutions to deliver and use inputs efficiently, manage systems, distribute and use outputs efficiently so as to avoid excessive wastage, and harness large-scale ecosystem services that benefit producers and consumers alike. However sustainable intensification is defined, it is necessary to achieve and sustain increased yields in ways that do not harm the resource base and the environment, and even improve them. In recent years, these conditions are beginning to be met in many parts of the world with the spread of Conservation Agriculture (CA).

Conservation Agriculture and sustainable intensification

The 'Green Revolution' paradigm for production intensification has been guided by: (a) the improvement of genetic potentials of crop and animal genotypes; (b) greater application of external inputs of agrochemicals for plant nutrition and pest (weeds, pathogens, insects, parasites) control; and (c) increased mechanical disturbance of exposed soil and terrain with tillage for crop establishment and other farming operations. The implicit assumption with this approach is that agriculture production systems are essentially closed and must be treated as such with the assumption that if more output is required, then more inputs must be applied. This approach is now known to be ecologically intrusive and economically and environmentally unsustainable, and leads to land and environmental degradation and sub-optimal factor productivities and yield levels that are difficult and expensive to maintain over time.

CA fits within the sustainable intensification paradigm of producing more from less purchased inputs; enhancing the resource base and its productivity and ecosystem service provision capacity over time. Thus, it is not intensification in the classical sense of greater use of inputs to obtain greater output but rather of the intensification of knowledge, skills and management practices and the complementary judicial and precise use of other inputs. In CA systems, outputs of desired products and ecosystem services are built on three interlocked principles of: no or minimum mechanical soil disturbance, maintenance of soil mulch cover and diversified cropping system. Practices based on these principles and supported by other "good agricultural practices" provide a robust and sustainable ecological underpinning to any rainfed or irrigated production system including arable, horticulture, agroforestry, plantation, pasture, crop-livestock, and mixed systems, thereby predisposing them to respond efficiently to any applied production inputs to achieve *intensification.* This approach does not attempt to have no impact on the environment, but to limit any environmental footprint to a level below the natural recovery capacity. At the landscape and large area level, CA offers large scale ecosystem service benefits that are not possible under tillage agriculture. Two well-known examples are the carbon offset trading scheme in Alberta, and the water services in Parana basin in Brazil (Kassam et al., 2013).

Many of the benefits under the no-till component and under the mulch cover component are not necessarily possible under tillage agriculture. Beneficial biological activity, including that of plant roots and soil microorganisms, thus occurs in the soil where it maintains and rebuilds soil architecture, competes with potential in-soil pathogens, contributes to soil organic matter and various grades of humus, and contributes to capture, retention, chelation and slow release of plant nutrients. The key feature of a sustainable soil ecosystem is the biotic actions on organic matter in suitably porous soil. Thus, 'conservation-effectiveness' encompasses not only conserving soil and water, but also the biotic bases of sustainability.

CA principles are universally applicable to all agricultural landscapes and land uses, with locally formulated adapted practices. Already, in 2010, CA had spread over more than 125 M ha of arable cropland globally (9% of cropland), and in 2013 the area under CA is about 155 M ha (10.9% of cropland). CA is an example of the agro-ecologically based sustainable intensification approach that requires lower amounts of all production inputs including energy, seeds, agro-chemicals, machinery, and time, and offers greater productivity than the non-CA counterpart systems. CA also provides an alternate approach to achieving sustainable intensification in low-input agriculture using traditional varieties and methods of maintenance of soil fertility.

Looking ahead

As with any new approach aiming to improve farming systems, adoption of CA has constraints that must be overcome. The spread of CA internationally offers lessons which show that constraints can be and are being overcome by farmers, rich or poor, large or small, through locally-formulated solutions involving a range of public and private sector stakeholders working together with farmers along different pathways of adoption (Jat et al., 2014). However, a more structured response to the opportunities presented by CA calls for a realignment of agricultural institutions and service providers, and greater investments in research, extension and education, as well as providing evidence for updating agriculture development policies to enable CA to become mainstreamed everywhere.

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Resource Saving and Productivity Enhancing Impacts of Minimum Tillage in Ethiopia

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Background
Minimum tillage is one of the few soil and water conservation practices introduced in selected areas of the Ethiopian highlands with the aim of tackling soil erosion, improving soil fertility and enhancing sustainable crop production. However, compared to other agricultural technologies like fertilizer and improved seed, adoption of conservation technologies including minimum tillage by smallholder farmers is very low (Aune et al., 2006). Although there are few reports that indicate the productivity advantage of minimum tillage in Ethiopia (e.g., Aune et al., 2006; Mesfin et al., 2011), it is not clear whether or not the gain in crop productivity could compensate for increased costs of production due to herbicide use associated with minimum tillage under resource-poor smallholder systems. Therefore, this paper aims at assessing the resource saving and productivity enhancing impacts of minimum tillage in maize-based farming system in South Achefer District, northwest Ethiopia.

Results
Results show that the probability of adopting minimum tillage is strongly associated to household resource endowment, access to input markets, age and education of household heads. Controlling for variations in plot and household characteristics, on average, the effect of minimum tillage on maize productivity is as high as 0.44t/ha if the same plot with similar household characteristics would have been used for maize production under conventional tillage. Compared to conventional tillage, adoption of minimum tillage decreased the average male and female labour use in maize production by 14.1 and 8.9 man-days per ha, respectively. Similarly, minimum tillage adoption decreased draft power use for land preparation by 13.9 pair of oxen-days per ha.

Applications and Implications for Conservation Agriculture
Though most researcher results confirm the long term benefits of conservation agriculture (CA) in attaining sustainable agricultural intensification (Arshad et al., 1999; Richardson and King, 1995; Govaerts et al., 2005), there is less consensus on its short term positive impacts attracting smallholder farmers to adopt the practice (Giller et al., 2009). Results from this study based on cross-sectional survey data confirm that there is significant resource saving and productivity enhancing impacts of minimum tillage under smallholders' setting in maize-based systems. The labor and draft power saving impacts of minimum tillage in maize production could benefit households that have limited or no labor and/or draft power endowment but have the capital (or access to credit) to purchase herbicides that usually are being used as complementary input to minimum tillage for weed control.

Experimental Approach
In this paper, plot and household level survey data collected in 2013 from 292 randomly selected households and 590 plots allocated to maize by the sample households during the 2012 production year were used. Combinations of methodologies were applied to check robustness of the analysis results. Between the minimum and conventional tillage plots, mean equality test was conducted for maize productivity, total labour use, male and female labour use for different maize production activities and draft power use in land preparation. Gross margin analysis was used to compare the average net returns from conventional and minimum tillage plots. With proper matching between the minimum-tillage and their counterfactual conventional tillage plots, Endogenously Switching Regression model and Propensity

Score Matching method were applied to estimate the impacts of minimum tillage in improving maize productivity and saving labour and draft power use in maize production.

Results and Discussion

Compared to conventional tillage, in general, there is a considerable short-run maize productivity gain and reduction in labour and draft power use under minimum tillage. However, the sustainability of maize production and productivity in the system might depend on the level of farmers' awareness and commitment in adopting the remaining conservation agriculture (CA) components such as intercropping, rotation of maize with legumes and crop residue retention for mulching and nutrient recycling.

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