WORLD CONGRESS 6 on CONSERVATION AGRICULTURE

JUNE 22-25, 2014

WINNIPEG CONVENTION CENTRE
WINNIPEG, MANITOBA

WCCA6.ORG

Session 11: Conservation Agriculture: Interfacing with Livestock Production

ORAL ABSTRACTS

Crop-livestock Integration in Conservation Agriculture Systems

Martin Entz
University of Manitoba

Perennial plants are considered among the most important contributors to soil and ecosystem health (Kunzig, 2011). Crop diversification with perennials contributes to conservation agriculture (CA), since perennial plants positively affect all three CA principles: permanent soil cover, crop diversity and minimal soil disturbance. Utilization of perennial plants typically involves ruminant livestock through pasture, forage or seed production activities. In western Canada, integrating crop and livestock enterprises provides economic benefits (Brewin et al. 2014).

A framework is presented that allows the attributes of CA systems with and without perennial forages to be compared. Considerations include the 3 main CA principles as well as animal and human health considerations (Table 1).

Table 1. Agriculture and health attributes as influenced by CA farming system type.

CA farming system	**Conservation agriculture attributes**			**Human health**	**Animal Health**
	Living soil cover	Crop rotation diversity	Minimal soil disturbance		
Grain only Eg., corn-soybean; barley-canola	-Intermittent	-Moderate diversity -Little deep soil root exploration	-soil disturbance low	Low due to poor fatty acid profile of animal products – high omega 6:3 ratio	Low due to long periods of confinement feeding
Grain only systems including late-season cover crops	-Near permanent	-High diversity -Limited deep soil root exploration	-soil disturbance low	Poor fatty acid profile – high omega 6:3 ratio	Low due to long periods of confinement feeding. Some late-season grazing possible
Forage-grain rotation. Eg. Alfalfa/grass-cereal-oilseed	-Near permanent	-High diversity -High subsoil root exploration	-soil disturbance low	Greater forage diet improves Omega 6:3 ratio	Improved due to greater time on pasture
Perennial wheat. Eg. Kernza	-Permanent	-Increased with legume interseeding -High subsoil root exploration	-soil disturbance through grazing	Most favourable Omega 6:3 ratio	High since animals only on pasture
Permaculture system with trees	- Longest seasonal duration of permanent cover	-Maximum plant diversity	-soil disturbance through grazing	Most favourable Omega 6:3 ratio	High plus animals have access to wider diet

Benefits of herbaceous perennials over grain only rotations include deep soil root exploration, a more permanent *living* soil cover and the opportunities to feed ruminants with herbage rather than grains (Table 1). The effects of perennial plants on subsoil have been documented for C sequestration in Uruguay (Gentile et al. 2005) and for nitrate scavenging in Canada (Entz et al., 2001). These are benefits that annual grain crops, even with the use late-season cover crops, cannot provide. Franzluebbers and Stuedeman (2009) demonstrated that soil carbon increases when perennial pasture phases were grazed instead of hayed, presenting a compelling argument for direct animal involvement in forage harvesting.

Grazing management within CA systems lacks research, though in Brazil Carvalho et al. (2010) determined that grazing animals must leave approximately 10 cm height of cover crops for no-till systems to accumulate soil organic carbon. New options for perennial-based CA systems include woody perennials in agroforestry, silvapasture and permaculture systems. Such systems may offer animals beneficial dietary diversity (Provenza et al., 2003) and great system biodiversity.

Red meat and milk from grass-fed animals contain higher concentrations of long-chain n-3 poly unsaturated fatty acids (PUFA) compared with concentrate-fed animals (Scollan et al., 2006). In a randomised, double-blinded 4 week test, McAfee et al. (2011) discovered that dietary intakes of total n-3 PUFA, as well as plasma and platelet concentrations of long-chain n-3 PUFA, were significantly higher in subjects who consumed meat from grass-fed animals compared with concentrate-fed animals.

Brewin, D.G. et al. 2014. Integration of forage, beef, and hog production systems in Western Canada: An economic assessment. Agric. Sys. 127:1-8.

Carvalho de Faccio, P.C. et al. 2010. Managing grazing animals to achieve nutrient cycling and soil improvement in no-till integrated systems. Nutr. Cycling Agroecosyst. 88, 259-273.

Entz, M.H. et al. 2001. Extraction of subsoil nitrogen by alfalfa, alfalfa-wheat and perennial grass systems. Agron. J 93:495-503.

Franzluebbers, A.J. & Stuedemann, J.A. 2009. Soil-profile organic carbon and total nitrogen during 12 years of pasture management in the Southern Piedmont USA. Agric, Ecosys and Enviro. 129: 28–36.

Gentile, R.M. et al. 2005. Influence of perennial forages on subsoil organic carbon in a long-term rotation study in Uruguay. Agric, Ecosys and Enviro. 105:419-423.

Kunzig, R., 2011. The Big Idea: Perennial Grains National Geographic April, 2011.

McAfee A.J. et al. 2011. Red meat from animals offered a grass diet increases plasma and platelet n-3 PUFA in healthy consumers. Br J Nutr.105:80-89.

Provenza, F.D. 2003. Linking herbivore experience, varied diets, and plant biochemical diversity. Small Ruminant Research 49:257–274.

Scollan, N.D. et al. 2006. Improving the quality of products from grassland. In: McGilloway, D.A.(ed.), Grassland: a global resource. Plenary and invited papers from the International Grassland Congress.

Dublin, Ireland, 26 June-1 July, 2005. Wageningen: Wageningen Academic Publishers.

Can Grazing Make Organic No-Till Possible?

Harun Cicek[1], Caroline Halde, Kristen Podolsky, Martin Entz, Keith Bamford and David Feindel
[1]ICARDA, Diversification and Sustainable Intensification of Production Systems Program
Amman/Jordan
h.cicek@cgiar.org

Background

Organic agriculture is criticized for its reliance on tillage to control weeds and mineralize N. Attempts to reduce tillage in organic systems have often focused on reducing, rather than completely eliminating tillage (Krauss et al., 2010). When tillage is completely eliminated, crop productivity in no-till organic systems is often significantly reduced as a result of N immobilization and weed competition (Halde et al, 2014). Tillage and green manure residue management are the greatest determinants of green manure N fate. Therefore, past organic research has focused on alternatives to intensive tillage for green manure residue management. Examples include mulching with the blade roller (Halde et al., 2014), using a wide blade cultivator or flail mower (Podolsky, 2013) and mowing using other machines (Blackshaw et al. 2010). One option that has received less attention is grazing. Grazing is known to improve N availability (Carvalho et al., 2010), reduce weed pressure (Hatfield et al. 2007) and prepare an appropriate seedbed for the next crop. Therefore, grazing can serve as a management tool to reduce tillage in organic agriculture.

Applications and Implications for Conservation Agriculture

Figure 1 illustrates the possible pathways, processes and factors involved in achieving organic no-till production. Two of the most common pathways are mulching and grazing of green manures. There are a number of processes (i.e. green manure utilization, N mineralization) and factors (i.e. green manure and ruminant species, weeds), which can influence organic no-till crop production (Figure 1). Research is needed in most of these areas. Achieving no-till through mulching green manures requires selection of plant species or mixtures for optimum decomposition rates, amount of biomass, and information on the suitability of implement type for green manure management (Figure 1). The green manure phase of an organic rotation is generally the most suitable for implementing reduced tillage to control weeds and the system is referred to as organic rotational no-till (Halde et al., 2014). For instance, using hairy vetch (*Vicia villosa* Roth) as green manure mulch, Halde et al. (2014) were able to reduce tillage for up to 2 years in Manitoba. However, after two years perennial weeds and limited N supply from mulched green manures hindered crop production.

To achieve no-till through the grazing pathway requires selection or plant species for optimum N, knowledge of utilization rates for ground cover, pairing of optimum ruminant and plants species, and finally, information on grazing intensity, which determines the N mineralization, ground cover and animal performance (Figure 1). Consideration of grazing as a tool in reducing tillage requires reexamining the role of cover crops, green manures, crop residues, catch crops and weeds. While majority of plant biomass can be considered as feed, livestock can be perceived as mower, terminator, land preparation and weed control tool and as a fertility enhancer. For instance, in Manitoba, late season barley (*Hordeum vulgare* cv. cowboy) and oilseed radish (*Raphanus sativus* L.) catch crops seeded after grazing green manures produced similar amounts of biomass under direct and conventional seeding (Cicek and Entz, 2013).

Green manure mulch remaining after grazing was in the range of 1500-2000 kg/ha (Cicek and Entz, 2013).

There is a widespread conviction that livestock and soil compete for mulch, and utilization of mulch by livestock compromises the objectives and the potential benefits of reduced tillage systems (Valbuena et al., 2012). Depending on the climatic region, there may be opportunities to combine grazing with reduced tillage systems such as mulching. For instance, Brazilian researchers found that grazing animals must leave approximately 10 cm height of cover crops for no-till systems to accumulate soil organic carbon (Carvalho et al., 2010). Similar information (i.e. grazing intensity and amount of green manure residue upon grazing) must be established for other ecosystems. Leaving large amounts of biomass on the surface in temperate regions may delay planting and plant establishment as a result of mulch keeping soil cooler in the spring (Halde et al., 2014). Low soil temperature, one of the difficulties facing organic no-till, may be significantly higher under grazed green manure plots. Higher soil temperatures in grazed areas in spring may facilitate earlier seeding of cash crops, which is an effective strategy for weed competition.

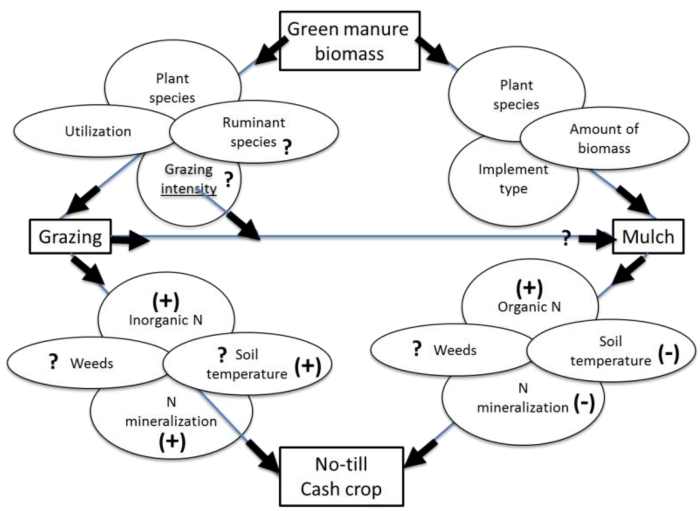

Figure 1. Processes and factors involved in achieving no-till organic cash crop production. Question mark (?) icons represent research needs and unknowns. Plus (+) and minus (-) icons represent increase and decrease in a given factor respectively.

References

Blackshaw, R.E., Molnar L.J. and Moyer. J.R. 2010. Sweet clover termination effects on weeds, soil water, soil nitrogen, and succeeding wheat yield. Agron. J. 102:634-641.

Carvalho de Faccio, P.C., Anghinoni, I., de Moraes, A., de Souza, E.D., Sulc, R.M., Lang, C.R., Cassol Flores, J.P., Terra Lopes, M.L., Silva da Silva, J.L., Conte, O., Wesp, C.d.L., Levien, R., Fontaneli, R.S., Bayer, C., 2010. Managing grazing animals to achieve nutrient cycling and soil improvement in no-till integrated systems. Nutr. Cycling Agroecosyst. 88, 259-273.

Cicek, H., Entz, M.H. (2013). Effects of autumn catch crops and tillage regime on soil nitrate leaching from grazed annual green manures. ASA, CSSA, SSSA Annual Meetings, Tampa, Florida, October 22-25, 2013.

Halde, C., Gulden, R.H., Entz, M.H. (2014). Selecting Cover Crop Mulches for Organic

Rotational No-Till Systems in Manitoba, Canada. Agronomy Journal.doi:10.2134/agronj13.0402

Hatfield, P.G., Lenssen, A.W., Spezzano, T.M., Blodgett, S.L., Goosey, H.B., Kott, R.W., Marlow, C.B., 2007. Incorporating sheep into dryland grain production systems II. Impact on changes in biomass and weed density. Small Ruminant Research 67, 216-221.

Krauss, M., Berner, A., Burger, D., Wiemken, A., Niggli, U., Maeder, P. 2010. Reduced tillage in temperate organic farming: Implications for crop management and forage production. Soil use Manage. 26: 12-20.

Podolsky, K. 2013. Reduced tillage implements for management of an organic green manure: Effects on nitrogen, weeds, and wheat yield. M.Sc. thesis. Univ. of Manitoba, Winnipeg.

Valbuena, D., Erenstein, O., Homann-Kee Tui, S., Abdoulaye, T., Claessens, L., Duncan,A.J., Gérard, B., Rufino, M.C., Teufel, N., Van Rooyen, A., Van Wijk, M.T., 2012.Conservation Agriculture in mixed crop–livestock systems: scoping crop residue trade-offs in sub-Saharan Africa and South Asia. Field Crops Res. 132, 175–184.

An Economic Evaluation of Crop and Crop/Annual Legume Pastures Rotation Systems in the Swartland, Western Cape

JA Strauss, MB Hardy (retired) and SJA Laubscher
Directorate: Plant Sciences
Western Cape Department of Agriculture, Private Bag X1, Elsenburg 7607, South Africa
JohannSt@elsenburg.com

Background

Rain-fed agricultural production systems in the Western Cape have been based on winter cereals since the 1700s. In the Swartland, located in the west coast region of the Province, wheat has been the main crop for the past century and was produced in monoculture with an occasional break of bare fallow or oats pasture. However, since the mid- 1900s and due to the region's inherent production potential for wheat, the advent of commercial fertilizers and improved chemical pest control measures, and government subsidies, wheat production was, until recently, based on mono-cropping. These factors also encouraged expansion of grain production into marginal areas (Arkcoll 1998). The establishment of annual legume pastures, that are adapted to the moist cool winters and dry hot summers, was encouraged during the land improvement scheme of the 1970s & 1980s with limited success, despite extensive research showing the benefits of including such pastures (annual *Medicago* and annual clover species) into a farming system in rotation with wheat (van Heerden 1998). Increased input costs, competitive world market prices and uncertain production due to decreased soil potential and variable, unpredictable rainfall, have greatly reduced the biological and economic sustainability of wheat production in the Western Cape. In this paper we undertook an economic analysis (to the gross margin level considering gross income, and direct and indirect allocatable variable input costs) of a large-scale, long-term experiment that compares several crop and crop/ annual legume pasture rotation systems. This was done in an attempt to determine the potential economic implications of including sheep production from annual legume pastures into the rain-fed grain production systems of the Swartland.

Results

Given the lower input costs and higher or similar gross margins and, therefore, lower financial risk, the results clearly illustrate the benefits of including annual legume pastures (with sheep production) into the rain-fed farming systems practised in the Swartland, Western Cape. The Swartland that receives >80% of its annual rainfall in the winter months, the inclusion of medic and medic/clover pastures and alternative cash crops such as canola and lupins into the cropping system provides an improved return on capital investment when compared to wheat monoculture (Hoffmann and Laubscher 2002).

Applications and Implications for Conservation Agriculture

One of the main beneficial effects of including legumes in cereal grain rotations is to reduce N inputs in the subsequent grain crop (Mcewen et al 1989). Nitrogen supplied by legumes has been shown in certain circumstances to disperse through the soil profile and is more effectively retrieved by wheat compared with surface applied N fertilizer (Lòpez-Bellido et al 1996). Medics and clovers have been shown to contribute to soil organic matter and provide 40 to 100 kg Nha-1a-1 to the soil profile, up to 40% of which is available to the subsequent crop (Ladd et al 1981). Grass weeds may be effectively controlled in broad-leaved crops and legume pastures thus reducing costs, and grass-weed competition and contamination, and increasing yields in the subsequent grain crop. The removal of grasses during the pasture phase prevents addition of grass seed to the soil seed bank thus limiting the potential for grass contamination and competition, reducing costs, and increasing yields in the subsequent grain crop (Le Roux et al 1995). Soil health improvement in terms of carbon increases especially in the crop/pasture systems where the soil is only disturbed every second year by a no-till planter was also evident with total soil carbon content increases from less than 0,5% to nearly 2% from 1996 to 2010.

Experimental Approach

No-till production practices (AUSplow) are used for all crops in the experiment. Data from the 2002 to 2010 seasons were included in the analysis. Eight rotation systems were compared, each with a 4-year cycle, viz. 1-wheat monoculture (WWWW), 2-WWWC, 3-WCWL, 4-WWLC, 5-WMWM, 6-WMCM, 7-WMcWMc-1 and 8-WMcWMc-2 (where W = wheat, C = canola, L = lupin, M = medic & Mc = medic /clover mixed pasture). In all cash crop systems all crop residues was left on the field following harvest, while crop/pasture systems were grazed during summer by sheep assigned to each system. At least 50% of crop residues remained on the field before planting the new crop.

Results and Discussion

Continuous cropping (systems 1 to 4) consistently had the highest input costs except in 2004 and 2006 when there were no differences ($P<0.05$) in input costs among systems. In four of the nine years, systems 1 and 2 had higher ($P<0.05$) input costs than all systems that included pastures (systems 5 to 8). System 6 tended to have the lowest input cost over all years. The high cost of fertilizer was a main contributor to input costs for the continuous cropping systems. The highest gross margins were obtained from the crop/pasture systems (systems 5 to 8) in most years although high input costs due to lime and phosphorous applications as well as certain herbicide applications reduced the margins in some pasture systems, in some years. While the monoculture tended to have to lowest gross margin over all years, system 8 tended to have the highest gross margin. The continuous cropping system 3 (WCWL) was most similar in gross margin to the crop/pasture systems in most years. Detailed statistical analyses of gross margin data derived from each treatment plot (camp) and based on 4-year averages for 2004 to 2010, confirmed these trends with system 8 (WMcWMc) having higher ($P<0.05$) gross margins than system 1 (WWWW) in all cases.

References

Arkcoll DB 1998. Crop diversification in the Western Cape. In: Troskie D P (Ed.). 'n Perspektief op die koringbedryf in die Wes-Kaap Provinsie. Departement van Landbou: Wes-Kaap

Hoffmann W & Laubscher J 2002. ‘n Finansiële evaluasie van wisselbou in die Swartland. Agrekon 41(4) 337-355

le Roux DJ, Agenbag GA & Mills LJ 1995. Grasbeheer in peulgewasweidings: invloed op die opbrengs potensiaal van opvolgende koringgraanplanting. Applied Plant Science. 9: 39 - 42.

Lòpez-Bellido L, Fuentes M, Castillo JE, Lòpez-Garrilo FJ & Fernandez EJ 1996. Long-term tillage, crop rotation and nitrogen fertilizer effects on wheat yield under rainfed Mediterranean conditions. Agronomy Journal 88: 783 – 791

McEwen J, Darby RJ, Hewitt MV &Yeoman DP 1989. Effects of field beans, fallow, lupins, oats, oilseed rape, peas, ryegrass, sunflowers and wheat, on nitrogen residues in the soil and on the growth of a subsequent wheat crop. Journal of Agricultural Science 115: 209 - 219.

van Heerden JM 1998, Selected aspects of applied research on legume pastures in the winter rainfall region. Elsenburg Journal: Commemorative edition: 56-63