Circular Agriculture – Policy, Science and Technology

Yangling, China, 5-7 November 2008

Summary Note

The inaugural workshop of the China-UK Sustainable Agriculture Innovation Network (SAIN) was held in conjunction with Yangling Agri-Science Forum, in Northwest A & F University, 5-7 Nov 2008. The theme of the workshop was "Circular Agriculture – Science, Technology and Policy".

The Workshop attracted over 60 presentations at the workshop under the sub-themes of circular agriculture, animal science and water resource management. A roundtable group discussion was arranged with focus on the development of SAIN.

The workshop was co-sponsored by RCUK China.

This summary note only referred the presentations directly relevant to the SAIN's four working groups, nutrient management, bioenergy, climate change and circular agriculture, with particular emphases on research needs and knowledge gap identified by the speakers.

Improve nutrient management

To achieve the levels of crop production required for food security, nitrogen (N) is an essential input to agricultural systems. However, it is vital for farmers and their advisors to estimate the quantities of N available from others sources within each cropping system and adjust fertilizer applications accordingly.

Tong's presentation shows that 85% farmer households over applied nitrogen in maize, and 40% of farmer households over applied nitrogen fertilizers in wheat production in 1998 in Shaaanxi, China. Lack of knowledge of nutrients balance and manure management is part of the reason of over use of chemical N fertilizer.

Optimising nitrogen use in agriculture

Powlson, Jarvis and Gilliland listed the following ways to improve N management:

- Understanding controls over farm nutrients - budgets and balances
- Understand the value of livestock manures (and their pollution potential)
  - provision of independent advice
  - backed by field experiments
- Optimise all inputs according to crop demands & pollution potential
- Understanding N losses and adopting new techniques for spreading (reduced ammonia loss). For example, comparing with splash plate, band spreader, trailing shoe, and shallow injector can reduce ammonia loss by 38%, 72% and 85% respectively.

- Change farmer attitude. In the UK, farmers recognise that manures contain valuable nutrients, but do not always take them into account
  - need to have clear messages
  - need to instil confidence
- Timing of mineral nitrogen applications
- Use of nitrification inhibitors or slow release fertilisers
- Improvement in the national GHG inventory

There is a significant potential to make organic fertilizer using solid organic wastes. However, low efficiency of technology and low market value constraint the development of organic fertilizer. Shen Qirong demonstrated the techniques such as inoculation of compost with highly efficient microorganisms and using efficiently tuning machine can improve the composting process. To make high value added compost products by mixing organic and mineral fertilizers and making Bio-organic fertilizers.

Policies for nutrient management in the UK

Jeremy Eppel introduced Defra's specific policies on nutrient management which include:

- Supporting industry to develop Nutrient Management Plans. The objective is to obtain industry and government consensus on the key elements of nutrient management planning on-farm.
- Publishing The Fertiliser Manual in partnership with the crop nutrition research community. An evidence based publication that will act as a key point of reference in support of a range of policies aimed at improving nutrient management on farms.
- Publishing the Code of Good Agricultural Practice (CoGAP). CoGAP is a practical guide to help farmers, growers and land managers protect the environment in which they operate. Offering interpretations of legislation and advice to help farmers avoid reduce pollution and protect their natural resources.
- Regulations such as Nitrate Vulnerable Zones (NVZs) and Catchment Sensitive Farming

Bioenergy

Principles and Criteria for Biofuel Crops

Jeremy Woods summarised the environmental standards for biofuel crops production which includes the following principles and criteria:

- Conservation of carbon stocks
  - Protection of above-ground carbon
  - Protection of soil carbon
- Conservation of biodiversity
  - Conservation of important ecosystems & species
  - Basic good biodiversity practices
- Sustainable use of water resources
  - Efficient water use in water critical areas
  - Avoidance of diffuse water pollution
- Maintenance of soil fertility

  - Protection of soil structure and avoidance of erosion
  - Maintain nutrient status
  - Good fertiliser practice
- Good agricultural practice
  - Use of inputs complies with relevant legislation
  - Use of inputs justified by documented problem
  - Safe handling of materials
- Waste management
  - Waste management complies with relevant legislation
  - Safe storage and segregation of wastes

Woods also addressed the importance of considering land use/availability, because:

- The main impacts and indicators for sustainability will be dominated by the land requirements
- Where agricultural and forestry residues can't be used then land-use-change will dominate
  - Even where residues can be used care will be needed (and regulation) to avoid over-exploitation and resulting declining soil carbon, organic matter and productivity
- Agricultural yield improvement must be a major focus of R&D

Integration of energy production and nutrient management in farming

Charles Banks pointed out some key issues need to be considered when integrate anaerobic digestion (AD) into the farming system:

- Conflict between nutrient demands and the times at which organic fertiliser materials can be applied may cause operational difficulties and lead to potential nutrient imbalances that need to be corrected by supplementation with inorganic fertilisers.

- Economic feasibility of energy schemes needs careful consideration, particularly when dealing with farm wastes which may have only a small potential energy yield per unit of volume, as is the case for example with cattle slurry.

- Policy makers to consider other benefits from on-farm AD:
  - the prevention of nutrient pollution of rivers and aquifers;
  - improvements in biodiversity through the return to more traditional but scientifically-managed farming techniques;
  - preservation of soil structure and organic content;
  - reduction of fugitive greenhouse gas emissions from the agricultural sector.

- Overall losses and gains associated with a reduction in methane emissions versus the potential for nitrous oxide emissions from application of digestates to farm land, and more research is needed in this area.

Climate change and agricultural adaptation

Adaptation challenge in China

Lin Erda presented China's study on adapting system for climate change and agriculture. The studies show that China's current vulnerability to climate variability and long term changes in climate is is dependent not only on the nature of climate event or change, but also on the social, economic and institutional context within which it occurs, which is also closely related to adaptive capacity.

Adaptation can delay dangerous impacts of climate change on agriculture through adaptation practices such as crop rotation, improved irrigation and water saving technologies, selection of planted crops based on changed climate and prices, adoption of heat resistant crops, and water efficient cultivars.

The challenges in adaptation include:

- the transfer of new technology;
- raising the profile of adaptation;
- integrating climate scenarios with other scenarios components;
- communicating uncertainty;
- integrating assessments and developing interdisciplinary research.

GHG emissions in food chain and implication to circular agriculture

Tara Garnett's presentation showed that:

- Food contributes to a significant proportion of global GHG emissions
- All stages in the supply chain contribute to emissions
- Global food demand is moving in more GHG intensive directions
- Food industry and government beginning to tackle problem but largely from 'efficiency' perspective
- Circular agriculture only makes sense in the context of sustainable consumption and nutritional needs

The following research needs were identified:

- What level of livestock production is needed to maximise environmental benefits, minimise GHG costs and enhance nutritional wellbeing?
- What policies would encourage a shift away from consumption and production of livestock products?
- How to integrate nutritional and food CC reduction objectives?

Rice field management and CH_4 emission

Farm field management can make a big difference in GHG mitigation. Cai Zucong demonstrated that CH_4 emission from rice fields are dependent on the soil moisturein the off-rice season and increase with the increase in soil moisture in off-rice season. Therefore, keeping rice field as dry as possible in the off-rice season is an important option for mitigating CH_4 emission from rice field during the rice growing period.

Pathways to low carbon

Trevor Davies pointed out various pathways to low carbon agriculture:

- Farm-scale greenhouse gas emissions inventory

  - GHG benchmark
  - carbon footprint
  - awareness raising
- Mechanisms of Nitrous Oxide Release
  - Enzymatic controls on nitrous oxide
- Carbon Sequestration and Soil Improvement
  - Biochar
- Non-Food Crops
  - Microplants as sources of materials
- Life Cycle Analysis

The challenge to create powerful pathways to a lower carbon future is to effectively combine the activities of new technologies and services in low carbon innovation with awareness raising, community engagement and actions.

Policies in the UK on agricultural mitigation and adaptation

John Gilliand and Jeremy Eppel introduced UK policies on agricultural mitigation and adaptation to climate change.

- The UK "Climate Change Bill"
  - The first in the World & a "Cross Party" Bill.
  - Compulsory Targets to reduce GHG emissions by 80% by 2050, against the 1990 baseline.
  - Committee on Climate Change to oversee & advise
  - To include all GHGs (methane & nitrous oxide) & all Sectors of the Economy
  - Allows for new Emission Trading Schemes through the use of secondary legislation

- Rural Climate Change Forum
  - Established in 2005
  - High level Forum for dialogue on GHG mitigation & Climate Change adaptation
  - Advises on Research, Policy and Communications to Government & Rural Stakeholders
  - Membership - Leaders from the breath of Rural Stakeholder Organisations
  - Helps steer the delivery of commitments in UK Climate Change Programme & liaise with new Committee on Climate Change**.**

Circular Agriculture

The concept and governmental support

David Norse highlighted the definition of circular agriculture which takes the closed system concept and reduce, reuse and recycle objectives of the circular economy and applies them to the agriculture along the whole production chain from upstream agro-chemical industries to end consumers.

There is a strong political will to develop/promote circular agriculture in China.

- In 2002, the Chinese government adopted the concept of circular economy
- In 2007, MoA set a action plan for circular agriculture, which included the activities of:
    - Promote energy saving & reduce emissions
    - Enhance development of rural biogas
    - Establish demonstration villages with fertiliser reduction, sewage treatment & crop residue utilization targets
    - Promote resource saving technologies
    - Increase biomass energy development
- In 2008, the Chinese government issued the Circular Economy Promotion Law.

Technologies of CA

Gao Wangsheng pointed the '4R' rules for the development of circular agriculture technologies:

- Recycle -for the renewable natural resource, such as climate, water etc, and for recycling matter resources between Crop-livestock-process system
- Reuse- for the reproductive resource, such as straw , excrements
- Reduce -for the purchased resources, such as fertilizer, pesticide, fuel energy
- Regulating -for the pollution emission materials, such as GHGs, NP pollution

Key techniques aimed at "reduce" rule

- Nitrogen cycle regulation
- Phosphor cycle utilization
- Biological Nitrogen Fixation
- Natural Enemies Utilization
- Biological Pesticides
- Bioremediation
- Minimum and no-tillage
- New type energy-saving machines

Key techniques aimed at "reuse" rule

- Straw straight return to field
- Return animal manure to land
- Straw ensiling technique
- Crops straws to fodder
- Crops straws to organic fertilizer
- Straws for producing edible fungus
- Biofuel
- Biomass products

Key techniques aimed at "recycle" rule

- Multiple cropping，
- Vertical cropping in farmland
- Conjunction of farmland and animal husbandry
- Conjunction of farmland and edible fungi industry

Key techniques aimed at "regulating" rule

- Non-point pollution control technique
- Biological control technique
- Methane (CH4) control technique
- Nitric oxide control technique
- Carbon sequestration technique

Oliver Doubleday, Chairman of East Malling Research and a farmer himself illustrated the linkage between farmers, researchers and innovation using examples practiced on his farm to increase efficiency, reduce input and protect environment:

- plant high numbers of apple trees on dwarf rootstock
- ring-barking trees to increase yield
- root pruning to control trees' vigour, a cheap technique that avoids the use of chemical treatment with a growth regulator.
- use of compost in orchards to improve yields and reduce fertilizer needs and irrigation demand
- deficit irrigation techniques by withholding irrigation water at various times improves the quality strawberries and maintains yield while reducing the amount of water used to produce the crop.
- picking trains to increase the efficiency of harvesting fruit

Integrated water management for circular agriculture

Both Phil Haygarth and Bill Davies addressed the importance of interdisciplinary approach in improving crop water productivity and reducing diffusion pollution

Some innovative approaches presented by Davies and Haygarth include:

- Immediate delivery of enhanced WUE via exploitation of novel signalling science
- Rhizobacteria as a novel way of decreasing stress sensitivity of plants
- Use of novel stress sensing techniques
- Delivery of big increases in WUE using sensing techniques linked to precise water delivery (DI) coupled with soil additives
- cost curve approach for mitigation option assessment by measuring cost and efficiency.

Policies in the UK and China

Jeremy Eppel introduced UK government Defra's Farming for the Future Programme as well as Defra's Strategic Objectives.

The long term vision for English farming is of a sector which contributes now and in the future to both environmental and food security. The Farming for the Future Programme is focussed on key priorities which will deliver the behaviour change necessary to realise that vision, at the same time setting a new direction for the relationship between Govt and industry.

Defra's strategic objectives integrate concerns of environmental sustainability in the farming industry:

- Climate change tackled internationally and through domestic action to reduce greenhouse gas emissions
- A healthy, resilient, productive and diverse natural environment
- Sustainable patterns of consumption and production
- Economy and society resilient to environmental risk and adapted to the impacts of climate change
- A thriving farming and food sector with an improving net environmental impact
- Sustainable Development championed across government, across the UK, and internationally
- Strong rural communities
- A respected department delivering efficient and high quality services and outcomes.

Although the structure & scale of UK agriculture is different its action plan is similar to Chinas with emphasis on energy saving, GHG reduction. David Norse summarised convergence & similarities for promote circular economy in the two countries:

- High political support
- Holistic view of needs and opportunities for improvement in the 3Rs
- Focus on waste minimisation & recycling
- Stress on raising resource use efficiency
- Importance given to innovation in S&T

Group Discussion with Focus on SAIN

Innovation

- Overcoming the scientific challenges
- How to communicate to farmers
  - How to ensure effective farmer representation on SAIN working groups?
- How to communicate to policy dialog
  - Research into new policy tools
    - How to get behavioural change – effective tools
    - Policy to inform science about key intervention areas

SAIN's mode of operation

- Role of the working groups established
- Produce paper on evidence base for each field and implications for gap analysis and policy development (c. 8 pages)
- Gap analysis
  - Identify experts /sources working in areas seen as 'gaps'
  - Dialog in working groups
  - Commissioning assessments
  - Followed by project proposal development (March 2009) to be submitted to the governing board of SAIN and then work will be commissioned

- Working Group papers published on website and through discussion fora
  - www.sainonline.org
- Develop network to enable and empower circular agriculture including low carbon agriculture (Working Group 4)
- SAIN in context of joint government Sustainable Development Dialog (SDD)
  - Continuous interaction between policy makers and SAIN research community
- Chairs of each working group to be in place by end of Nov08

Gap Analysis

- Soils – understand possible perverse outcomes
  - Use of micro-organisms
- Definition of systems that are being targeted
  - E.g. of cropping system / farming structure being targeted
  - Systems modelling and Life Cycle Analysis
  - Applied social, economic and environmental analysis
- Animal production systems – feeding, nutrient management, Enteric fermentation
  - Use of organic waste streams
- Quantification of biomass resources available
  - Including household waste in rural areas
- Cycles of nutrients and pathogens
- Communication and application
  - from science to the field, and;
  - from science to policy
- Policy research (new mechanisms for new issues)

Possible WG 1 activities

- 'Policy clash analysis' – perverse policy making
- Establish evidence base for each field, then gap analysis
- Are there novel cropping systems that can achieve Circular Agriculture's aims
- Establish system boundaries for each of the working groups

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