Biogas Feedstock Production Using Novel Crop Rotations with a Closed-Loop Nitrogen Supply

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A new research project on bioenergy crops is under way, funded through FRST using Sustainable Land Management for Climate Change (SLMCC) funds from MAF. It is called Closed Loop Nitrogen (CLN) Supply Crops for Biofuel. Research on the biogas aspects is led by Biogas Interest Group (BIG) members Rocky Renquist (Plant & Food Research, Palmerston North) and Stephan Heubeck (NIWA, Hamilton). The SLMCC fund is targeted at projects that further agricultural green house gas (GHG) mitigation, agricultural climate change (CC) adaptation as well as provide novel rural business opportunities. The CLN bio-energy crops project has the potential to advance all three of these goals.

The core principle of the proposed scheme is to employ well proven anaerobic digestion technology to provide biogas, displacing fossil fuel use in rural transport, on-farm vehicles as well as heat and electricity provision in the agricultural sector. The biogas is derived from energy crops that are grown with minimal external inputs on marginal land, where energy cropping may offer numerous environmental benefits (such as reduced nutrient leaching, , enhanced ground water quality and quantity etc.) in comparison to traditional farming practices. The relatively small unit scale and distributed nature of bioenergy cropping and processing will ensure the majority of the value generated via the scheme to remain in the hands of farmers and the closely related service sector, providing an economic stimulus to often neglected rural areas.

The primary opportunity for reduction of GHG emissions within the proposed scheme is from the displacement of fossil fuel use by farm equipment and rural trucking, which consume between 10 and 20 PJ fossil fuel p.a. depending on definition/classification. Substitution with bio-fuel on this scale, i.e. ~ 7% of current New Zealand petroleum fuel use (NZ Ministry of Economic Development, 2009), can hardly be met by wastes/residues alone and requires purpose-grown energy crops, in particular since many waste streams are concentrated around population centres and are therefore better utilised in an urban setting.

Therefore, the research will design a novel energy crop production system that, as a second mitigation effect, reduces GHG emissions from the manufacture of nitrogen (N) fertiliser. This will be achieved by virtue of its 'closed loop N supply' feature. A key characteristic of anaerobic digestion is that the plant nutrient value of the input feedstock is retained during bio-fuel (biogas) production. Plant nutrients can be recovered from the AD process in the form of a nutrient-rich slurry (digestate), which is a valuable and versatile agricultural fertilizer. Therefore combining a carefully selected crop rotation based on highly productive N use efficient annual and perennial crops (some of them legumes) with energy production via anaerobic digestion can not only retain the nitrogen to supply the cropping system, but may be able to generate a surplus of fertilizer nutrients that could be used for food crops or pasture. For that reason linking biomass cropping to biogas production can replace large volumes of N fertiliser manufacture (using fossil gas) that these crops would alternatively have required. In comparison to other biofuel production systems the parasitic energy consumption of biogas systems is very low, and due to the versatility of biogas as a fuel for transport, heat and electricity applications, the system does not necessarily require any external energy inputs.

Adaptation to CC is served by the proposed new cropping system, both by new findings on use of marginal land (which as a result of CC, will be more abundant in the future) and by testing of cultivars with sub-tropical parentage that are adapted to warmer climates. Use of this system on marginal land, where these energy crops will not compete with food crop production, will contribute to MAF's CC policy goals on land management.

Although the project is only for 3 years the research will test the closed loop N supply concept (CLN) by quantifying the main elements of such a system and integrating results into a 'virtual CLN' model. The biomass crops under investigation include new annual cultivars with high nitrogen (N)-use efficiency in combination with N-fixing legumes. Perennial crops, including legumes, will also be emphasized. Another component is that different crop rotations will use different kinds of marginal land, which are defined carefully, so that appropriate crops will be matched with each type of marginal land. The project will also help assess whether sustainable biomass production is also possible within rotations on crop land.

Uptake of this new sustainable energy crop production and processing system will create business opportunities, increase the value of marginal land and sustain rural communities with a secure, affordable source of fuel, while reducing the NZ trade deficit. Some of the market for biomass growers will be created by AD facilities already being built by intensive livestock operations to address environmental problems by converting manure to biogas. Their AD plants will be more cost effective if they incorporate energy crop biomass since it yields more biogas per tonne than manure. Several new service businesses would be supported by an emerging new biofuel cropping sector, including feedstock crop breeding by seed companies and transport and processing of both biomass feedstock and biogas digestate by agricultural contractors, possibly utilising biogas-fuelled vehicles. Civil and mechanical engineering as well as consulting jobs would be created for the construction of anaerobic digester plants, biogas upgrading plants and vehicle conversions. Furthermore high and low skilled jobs for operating these facilities would be created in rural areas, many of which would greatly benefit from additional employment opportunities.

This project will be carried out in collaboration with world-leading overseas research teams with in-depth knowledge on quantifying and projecting biogas yield potential from different crop materials (Austria) and utilising subtropical plants (such as sorghum) for biogas production in temperate climates (Germany). The project will have strong links with existing programmes on land use (SLURI) and one that engages Māori communities (the Best of Both Worlds). The outcomes of this project could provide a step change in the environmental, economic and social sustainability of biofuel production in NZ.