2: Crops for bioenergy production—an exciting new option

Sustainable Bioenergy Cropping Systems

Introduction

Substitution of fossil fuels with biofuels has been identified as an opportunity to reduce the agricultural greenhouse gas (GHG) footprint in NZ. The availability of high energy waste that can be used for biofuel production may be limited or not available where energy need is required, motivating recent research into the potential for purpose-grown bioenergy crops.

What is a bioenergy crop? It is a crop that is purpose-grown for the production of renewable fuels such as biogas. These crop systems are well suited to perennial plants as the crop needs to produce significantly **more renewable energy than the energy** consumed in growing the crop.

Options for bioenergy production: monoculture crops grown on fertile soils (e.g. maize, oilseed rape, and sorghum); waste biomass (e.g. dairy and pig effluent, wood waste, vine prunings) and mixtures of crops grown with low inputs (cropping systems using Jerusalem artichoke, miscanthus or tickbean) or with recycled inputs (sorghum using biogas digestate).

Desirable plant characteristics: High dry matter (DM) yield, high digestibility of all above-ground plant parts, low ash content, low fertiliser requirement, easy to establish and tolerant of particular site limitations of the soil or climate, perennial growth habit or amenable to minimum tillage, high pest tolerance, easy to harvest, ensilable, and a high biomethane yield (>250m^3/tDM).

Growing area: Most New Zealand regions are suitable, but the best fit is to use 'marginal' sites rather than prime arable land. Inevitably, land availability will depend on the potential value of a bioenergy crop compared to alternative land use options.

Closed-Loop Nitrogen Supply (CLN) cropping system: (refer to Fact Sheet: Growing energy while cycling nutrients on-farm). A key feature of the anaerobic digestion process is that plant nutrients can be recovered in the form of nutrient-rich slurry (digestate), which is valuable as an agricultural fertiliser. Combining a crop rotation based on highly productive and nutrient and water use efficient perennial and annual 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 fertiliser nutrients that could be used for food crops or pasture. CLN is, therefore, a novel energy crop production system with the potential to reduce Greenhouse Gas (GHG) emissions from the manufacture of nitrogen (N) fertiliser as well as from the fossil fuel substituted by biogas energy.

Preferred crop species and rotations

Trials done by Plant and Food Research have identified forage sorghum (*Sorghum bicolor*) with a companion winter legume and Jerusalem artichoke (*Helianthus tuberosus*) as potential varieties for marginal land as they were both high yielding and relatively drought tolerant.

The best two sorghum cultivars (*Sugargraze* and *Jumbo*) yielded >25 tDM/ha in trials in the warm climates of Kerikeri and Hastings with adequate water. Sorghum DM yields in sites that are more marginal (cooler or drier) were calculated using crop models to be greater than 15tDM/ha.

Jerusalem artichoke, March 2012, 2 weeks before harvest

In the trial work the preferred winter legume species to use with sorghum were tickbean (*Vicia faba*) and crimson clover (*Trifolium incarnatum*). Hawke's Bay winter trial plots of crimson clover yielded 9.6tDM/ha and tickbean exceeded 20tDM/ha under favourable winter conditions in prime soils. Lower yields would be expected in paddocks with more variable soil and climate conditions i.e. up to 7tDM/ha and 15tDM/ ha for the two species.

Since much of the N in both sorghum and legume are recycled with the application of the digestate, there is no need for supplemental N fertiliser in this CLN cropping system. The sorghum/tickbean rotation in particular should give a net surplus of N-containing digestate that could be used on other crops.

The trials identified Jerusalem artichoke as a favourable CLN crop for the South and lower North Island. As a perennial, yields will vary between establishment and subsequent years, but results from trials in favourable conditions were above ground yields of at least 25tDM/ha. Jerusalem artichoke survives drought and has high nutrient use efficiency. In 'marginal' conditions, paddock yields of 15 tDM/ha appear reasonable. It cannot be grown as a perennial in regions warmer than Hawke's Bay since seed tubers need chilling for buds to sprout properly. As a perennial crop Jerusalem artichoke can be grown with less long term input cost and effort compared to annual crops.

For the cooler regions of NZ other high yielding crops such as triticale or lucerne may be digested for bioenergy. Triticale would be grown in rotation with a legume or (like Jerusalem artichoke) could be fertilised with digestate from lucerne. Basing an anaerobic digestion energy crop system on several species will ensure higher levels of yield security, and facilitate other agronomic outcomes as part of a sustainable farming system. Further research on potential yields and returns needs to be done.

Opportunities and Risks

- There is potential for significant GHG mitigation opportunities within both the CLN cropping system and anaerobic digestion technology:
  - to substitute biofuels for fossil fuels used on farm,
  - to substitute recycled crop nutrients from anaerobic digestion digestate for manufactured fertilisers.
- CLN cropping systems are best with a perennial crop that requires fewer annual tractor operations, which improves the ratio of renewable energy output to non-renewable energy input for growing the crop. GHG emissions from soil during annual cultivation are also avoided. These systems are dependent on growing a legume within the CLN system, which produces nitrogen to cover the 15-20% that may be lost as N within the crop is recycled from year to year. There is potential to grow bioenergy crops on land less suited for other arable crops.
- Anaerobic digestion technology requires significant capital investment and experience. The return on investment is affected by the cost and availability of fuel alternatives.
- There is a need to develop skills in design and management of local or on-farm anaerobic digestion systems.

The key for a successful biogas sector in NZ will be to develop individual solutions for each situation, trying to maximize synergies between energy and food production, together with other environmental, security and rural development goals. Further research is required to evaluate potential crops, reliable crop yields, and energy density of the crop.

FAR · Horticulture New Zealand · Tahuri Whenua National Maori Vegetable Growers Collective · Ministry for Primary Industries Manatū Ahu Matua · LandWISE Incorporated