PFS Consultants Limited

MxG for Sustainable Renewable Energy.

The Crop You Probably Know Nothing About

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The Proprietors of Taharoa C Block (Taharoa) began work on a wind power project in 2004. The location of this project was to be on their land which was covered with mature or semi-mature radiata plantation forest. Because trees and wind power do not mix well, plans were made to harvest the trees and not replant.

Because Taharoa did not want to have the land under the turbines lying idle, investigations were started into determining how the land could be used productively in a way that did not impinge on the wind power. Growing a bioenergy crop was one of the areas of interest for this land use. The criteria for such a crop were that it had to be able to grow well on low fertility land, did not get more than a few metres tall, and was sufficiently productive to give satisfactory economic return. It had also to be compatible with and useful as a feedstock in processing technology that is existing or imminent.

THE PLANT

The plant that was settled on was *Miscanthus x giganteus*. This is sometimes erroneously referred to as Elephant grass, but we have decided to refer it to it as MxG as a unique and distinctive name that also distinguishes it from the species of Miscanthus, some of which can be invasive plants.

Figure 1. Four year old MxG in Illinois (Photo **PFS)**

MxG is a naturally occurring sterile triploid hybrid C4 grass that originated in Japan. It was taken to Europe in the 1930s and has been grown in trial areas throughout Europe, in some cases for over 30 years. It is grown commercially in the UK with supply in the order of hundreds of thousands of tonnes being produced and marketed to end users.

Once planted, MxG is harvested annually with full production being reached after three years and being maintained for at least the next 15 years. It does not need replanting each year. Because of its

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ability to translocate nutrients from the leaves to the rhizomes in the autumn, the winter harvest removes very few nutrients from the site. As a result fertiliser application is generally not needed, or if needed is required in very small quantities. Trials in Europe have shown no response to application of nitrogen fertiliser.

Because MxG tends to drop its leaves after the nutrients have been translocated to the rhizomes, it forms a very thick mulch layer that suppresses weeds. As a result, after the first year, weed control is generally unnecessary.

MxG grows to a height of 3 – 3.5 metres when in full production. To do this it requires a minimum rainfall of at least 600 mm. However because it is very deep rooted, it can withstand dry periods once it is established. And because of this deep rooted nature and the slowly extending network of rhizomes that it establishes near the surface, it is also excellent in terms of soil stability.

In other countries it is almost always grown from rhizome cuttings, but because of the need to import it into this country in tissue culture form, in New Zealand the initial establishment at least, will be from establishing plantlets that have been developed in the laboratory and then grown on and multiplied in the greenhouse.

Figure.2 30,000 MxG in NZ greenhouse 2009, grown from a handful of tissue cultures. (Photo **PFS)**

UTILISATION POTENTIAL

One of the advantages of MxG is that it is very versatile in its use. The original thinking of Taharoa was aimed purely at production of liquid fuels. As we have learned more we have realised that the potential is considerably greater than this. There is existing technology and there are existing markets that would happily take all the MxG that we could produce right now.

LIQUID BIOFUELS

The original thinking in terms of liquid biofuels centred on production of cellulosic ethanol. New Zealand technology has been developed with the objective of converting Salix into high value S-lignin for use in adhesives or bio-plastics, and ethanol. A sample of MxG that we have had tested through the system showed itself to be very suitable and MxG may in fact be better than the Salix when it comes to ethanol production. We are told that this technology is currently at the stage where a pilot plant is being built.

Research work being done internationally, particularly at the University of Illinois, has shown that it is also theoretically possible to make biodiesel from MxG. And by use of rapid pyrolysis it is also possible to make the liquid fuel BioOil - a fuel that can be used directly for electricity production or through further processing as potential to make biodiesel.

DIRECT FIRING

Internationally, direct firing is the most common current use. A large power station in the UK currently takes approximately 300,000 tonnes per year of MxG and has plans well advanced to expand this significantly. They use MxG to take the place of some of the coal that they previously burned and they have also signed up to construct three stand-alone 300 MW biomass fired power stations in the next several years.

Figure 3. Four year old MxG in Illinois. (Photo **PFS)**

BIOCHAR

MxG, along with almost all other organic materials can be made into Biochar. Biochar itself has a myriad of uses, the most interesting of which is application to agricultural soils to enhance fertility on a permanent basis while also permanently sequestering the carbon in the soil. The first Biochar production plant in New Zealand should commence construction within the next twelve months. The whole subject of Biochar is extremely relevant to New Zealand primary industry businesses but would require a separate paper to cover it properly.

BIOGAS

MxG also has the capacity to be used for the production of biogas through a fermentation process and could easily be combined with various forms of effluent to enhance the production of biogas.

OTHER

MxG is palatable to animals so one of the things that we will be looking at is its potential for being grown as a supplementary animal feed. To that end, we will be getting samples of our initial trials assessed for nutrient content at various stages during the growing season.

TAHAROA'S CURRENT ACTIVITY

Having identified the plant that seemed to be the most suitable for our purposes, the initial challenge was to get permission to bring it into New Zealand.

Figure 4. MxG in the greenhouse ready for planting. (Photo **PFS)**

REGULATORY APPROVAL

Regulatory approval was required from two agencies.

The first was Environmental Risk Management Authority (ERMA). The staff of ERMA proved to be professional, very good at their jobs, and they had a strong appreciation of commercial realities. As a result the application process was relatively straightforward and happened much more quickly than we expected.

All the costs were also very reasonable and the fee was extremely low. The ERMA staff assisted us where they could, insisted (quite correctly) on things being done thoroughly to the point of almost being pedantic, and then wasted no time in getting independent corroboration from international sources and making a final decision.

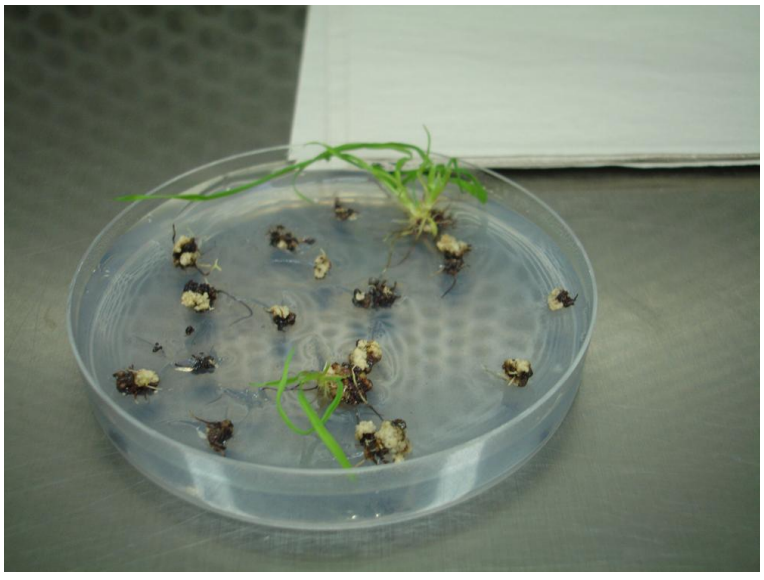
The second agency from which we required regulatory approval was Biosecurity New Zealand – a division of MAF. In order to bring any plant into New Zealand, once it has been approved by ERMA it has to have an Import Health Standard (IHS) written. The IHS is a document that describes how a particular plant can be brought into New Zealand so as to ensure that there is a suitable level of biosecurity protection in the process. It is an important part of import control, but the section within MAF that deals with this is not well staffed, has a huge number of applications each year, is bound by a very bureaucratic system and is severely constrained by the system in how quickly such work can be completed.

Taharoa agreed to pay to have the Biosecurity Risk Analysis completed and the IHS to be written, so that it would happen more quickly. But the final release of the IHS was then held up at the last hurdle by an unrelated Court of Appeal decision. The IHS was finally approved in August 2008 - eighteen months after Taharoa had agreed to pay to get done.

PLANT IMPORT

In order to speed things up however, Taharoa had received approval from both ERMA and MAF to jump the gun a little by bringing some MxG into New Zealand in advance of the regulatory approvals, providing it was retained in a Level 3 quarantine laboratory. This enabled us to begin work on tissue culture multiplication pending the approvals coming through, and conscious of the fact that if approvals were not granted we would have to either destroy or re-export the material. This enabled us to get a certain amount of commercial advantage by being the first mover. We needed this advantage in order to justify the expense involved in obtaining the ERMA approval and getting the IHS completed.

Figure 5. First 4 plants from embryogenic tissue of MxG. (Photo **The TreeLab**)



TECHNOLOGY DEVELOPMENT

In the laboratory, the staff developed new ways of multiplying MxG in tissue culture. The most exciting was the development of the ability to take somatic embryogenesis tissue and get it to form plants. This had not been done anywhere else in the world and there is already international demand for access to this technology.

At the same time, the standard multiplication of organogenesis was being refined with the aim of being able to produce large numbers of plantlets in a relatively short time at a reasonable cost.

As soon as the initial plants were available and the approvals were in place, we got plants out into a greenhouse and proceeded to start work on multiplication of plants within the greenhouse. This

work is still being refined but indications are that we will be able to multiply plants very quickly in the greenhouse at a cost that is considerably cheaper than using tissue culture methods.

INITIAL TRIALS

Initial small-scale trials have been planned and providing funding is available, are about to be planted at several sites around New Zealand. Most are on Maori land, because this type of land ownership is ideally suited to the growing of a longer term crop like MxG - you know who the owner will be in 15 years time, unlike general title land. Also Maori land tends to come in larger lumps making cultivation of large areas in one locality much more straightforward. Maori properties also have a disproportionate amount of marginal land, which is exactly the niche land type on which it is intended to base an MxG industry.

Taharoa and its partners should know the early results of these trials by Christmas.

Figure 6. MxG in NZ 4 months from planting in a pot – 1.2 metres tall with restricted root run. (Photo **PFS)**

Providing the work of bulking up plants continues to be successful and suitable funding becomes available, the intention is to plant larger operational-scale areas in the Spring of 2010. The range of places in which trials will be carried out will also almost certainly also be expanded.

INTERNATIONAL INTEREST

As mentioned earlier, there is already international interest in some of the technology we have developed. However we have also discovered that there is a significant international shortage of MxG plants and we have already received our first order for supply of plants to the USA. Because our techniques enable multiplication of larger numbers quite quickly and cost effectively, people appear to be happy to pay to be able to use this technology for their own multiplication systems.

There is also international interest in purchasing the harvested product of MxG that we intend growing in New Zealand. This interest is serious enough that representatives of a large overseas coal-fired power generation company have already visited New Zealand twice to discuss the potential for us to supply them with feedstock in the future. And a very big overseas pellet producer is in discussions with us regarding the possibility of the their expanding into New Zealand to set up an export focussed pellet producing plant that is based at least partly on MxG.

CARBON BENEFITS

For the people who are interested in reducing the amount of carbon dioxide going into the atmosphere, we can also claim that there are significant carbon benefits. In order to quantify the magnitude of these benefits, we worked out how much CO2 would be absorbed over a 28 year cycle on one hectare so that comparison could be made with a radiata pine plantation. The results are shown in the table below.

Crop	CO_2 Absorption over 28 years per hectare
Miscanthus	1,230 tonnes
Radiata pine	725 tonnes

The key assumption is that when the MxG is harvested it is used to replace a fossil fuel such as coal or a product of crude oil, so it is in fact, permanent sequestration in that the coal or oil it replaces stays in the ground. The CO_2 absorption for the radiata pine comes straight from the MAF carbon sequestration tables. What is not stated is that radiata figure is the amount that is absorbed over 28 years and is then considered by the authorities to have all been released back into the atmosphere at harvest time. So if a radiata plantation is harvested at 28 years radiata's net CO_2 absorption is considered to be zero.

The benefits are clearly considerable, and on the basis of this we are having discussions with the government in order to try to get the replacement of radiata pine forest with MxG to not be counted as deforestation.

NEXT STEPS

With a project such as this there is always further work to be done. Some of these next steps are as follows:

We need to

- Establish and assess the trials.
- Make a decision - before we have all the trial data – whether to continue with bulking up large numbers – i.e. tens of millions of plants, with the associated significant level of expenditure - so that operational-scale planting can be carried out during the Spring of next year.
- Establish appropriate commercial structures for this expansion and identify the large production areas that will be needed.
- Continue to market Taharoa's technology and our capacity to carry out international production and sales of plants.
- Guard Taharoa's Intellectual Property carefully so that the significantly large investment that has already been made and continues to be made, can be justified.

- Continue to cultivate commercial partners who can add value to what Taharoa is doing and who can benefit from the new MxG industry that we are establishing in New Zealand.

CONCLUSION

This is a very exciting new crop that has huge potential for New Zealand. It is particularly relevant to farmers who are struggling to break even with conventional farming on land that is not arable. With the qualification of having to be able to traverse the terrain with machines for harvesting, there appears to be quite a large amount of suitable land in many areas of New Zealand that is well located with respect to potential MxG utilisation plants.

With our focus beginning with Maori properties, we inevitably are working on a solution that will solve some of the problems of general New Zealand farmers who are not currently doing well commercially.

And with our other focus being on reduction of greenhouse gases in the atmosphere, we are heading rapidly towards a point where we may be able to contribute significantly to shrinking the overall agricultural carbon footprint and in the process, assist landowners, primary industry and New Zealand as a whole.

Figure 7. 20 Year of MxG trial plot in Illinois. (Photo **PFS)**