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From Project Coordinator: Welcome to MISCOMAR Project

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Dear Readers,

Welcome to the issue no. 1 of the MISCOMAR Newsletter. As Project Coordinator, together with my colleagues from Great Britain and Germany, I would like to introduce our project.

What is MISCOMAR

MISCOMAR is a three-year research project under the flag of the Era-Net Cofound FACCE SURPLUS - Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI). MISCOMAR actions are an integrated chain of activities designed to deliver on the strategic objectives of FACCE.

The aim of the project is to determine the technical potential of novel *miscanthus* hybrids to deliver biomass production options on marginal and contaminated land and to determine and quantify the changes in soil health and structure under these crops.

What will be investigated

MISCOMAR will investigate the potential of *miscanthus* biomass production on marginal lands including heavy metal contaminated (HMC) arable soils. Changes in soil carbon and structure under *miscanthus* plantations will be quantified to determine the environmental effects. Different *miscanthus* biomass end uses from marginal and contaminated land will be valorized in order to find a proper way of integrating *miscanthus* into existing farming systems that will result in positive environmental and economic values.

Test sites

At the heart of the project there are measurements that are made on the plants at three field trial locations: a heavy metal contaminated arable land in Bytom (Poland); high clay content, waterlogged soils in Unterer Lindenhof (Germany) and nutrient depleted soil, intensively used in the past (Lincolnshire, Great Britain).

Project Team

MISCOMAR is implemented by an international consortium of 3 institutes:

- **Institute of Biological, Environmental and Rural Sciences (IBERS) of the Aberystwyth University from Great Britain,**
- **University of Hohenheim, Biobased Products and Energy Crops Department (UHOH) from Germany,**
- **Institute for Ecology of Industrial Areas from Poland.**

Terravesta Ltd. is a supporting industrial partner that has been working with IBERS to develop the commercial potential of the new *miscanthus* hybrids.

The **IBERS** team involves the research group of Prof. John Clifton-Brown, with assistance from Dr. Jon McCalmont -- experts in the field of *miscanthus* breeding and field trials and the largest collection of *miscanthus* germplasm in Europe with 1500 accessions. They provided *miscanthus* germplasm from their breeding programme as well as maintaining and monitoring the existing reference trial site (Lincolnshire). IBERS is also responsible for such key activities as the overall coordination and performance of time series soil sampling across partners' trial sites; analysis of soil samples for texture and carbon content; as well as development of a soil database and ensuring its compatibility with field data acquisition tool/protocols..

From UHOH, the Department of Biobased Products and Energy Crops - lead by the well-known miscanthus expert Iris Lewandowski - is involved in MISCOMAR with the two scientists Andreas Kiesel, leader of UHOH sub-project, and Anja Mangold. The research of the department addresses concepts for sustainable biomass production and supply. They deal with issues of perennial energy crops, crop residues and grassland as feedstocks for bioenergy, biomaterials, nutrient recycling, biomass quality and systems analysis. The main tasks of UHOH in the MISCOMAR project is to perform a field trial on a marginal arable land, quality analysis of the biomass samples collected at each site and the development of the holistic concepts for *miscanthus* integration in existing crop rotations and various landscapes.

These two research groups are complimented by the Environmental Remediation research group from **IETU** that includes Dr. Jacek Krzyżak and Szymon Rusinowski and me as a leader. Our area of expertise is application of environmentally friendly technologies to the environmental restoration of contaminated, post-industrial sites. In MISCOMAR IETU provides the overall coordination and dissemination of the project, we also run one of the field trials – at the Bytom site. IETU team is responsible for the assessment of the biomass quality collected from project field trials and contributing to the development of the concepts for integrating *miscanthus* in existing crop rotations and landscapes.

I hope with this introduction I managed to raise your interest in our project. Please contact us if you need more information. I encourage you to follow our advancements on our web site www.miscomar.eu, via ResearchGate https://www.researchgate.net/project/MISCOMAR or LinkedIn https://pl.linkedin.com/in/miscomar-project-460a3a128

This project is carried out under the flag of ERA-NET Cofund FACCE SURPLUS in the frame of the Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI)

Land contamination in Europe

More than 2.5 million sites among 38 European countries are potentially contaminated, and 342,000 sites have been identified as contaminated. The principle causes of this are municipal and industrial wastes (responsible for 38% of the total contaminated land area) and production of raw materials, production and distribution processes of the industrial and commercial sectors (34% contaminated land area.

The most prevalent types of soil contaminants in Europe - mineral oils and trace metals, including lead, arsenic, cadmium, and mercury - together contribute to 60% of soil contamination.

Miscanthus and marginal agricultural land, a UK perspective

by *Dr. Jon McCalmont*,
Aberystwyth University,
Institute of Bilogical, Environmental and Rural Scientices,
United Kindom

Marginal lands in the UK

In the UK, agricultural land is divided into 6 quality classes, primarily driven by soil quality. These run from the best, grade 1, to the worst, grade 5. Grade 3 is split into two, 3a and 3b with the distinction between the two determining excellent (grade 1) to good (3a) and moderate (3b) to very poor (5). For England and Wales grades 3b to 5 make up about 60% of all farmland with a further 20% in grade 3b. Land can be placed into these marginal classes for a range of reasons, from poor physical quality or nutrient depletion to difficult site access or even seasonal waterlogging making cultivation problematic. Crops that can be grown in these conditions, and even help in the improvement of them, can be of paramount importance on these soils.

Land poor in nutrients

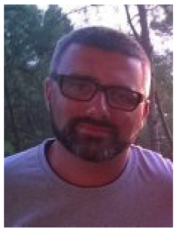
For the UK site in the MISCOMAR project it is primarily the depletion of nutrients, particularly potassium and phosphate that create the marginality of the soils. Results from our baseline sampling and analysis found on average there was 7 times as much potassium found at the other MISCOMAR sites as there was at the UK one, 15 times as much phosphate and twice as much Magnesium. Only in nitrate did the UK site have comparable levels, the residue of long term, unsustainable arable production.

In addition to this, and exacerbating the problem, the soils themselves are also marginal by their physical texture. Texture analysis found the soils at this site to be dominated by clay. This clay, particularly heavy below about 15cm, presents an impervious barrier preventing rain water draining away down into the lower depths, this heavy clay texture means that in times of high rainfall the site very quickly becomes waterlogged, creating huge problems for machinery access. This brings significant challenges for annual crop production, repeated ploughing and herbicide/fertiliser tractor applications mean that the soils are continually compacted, requiring further ploughing and tillage to rectify in an ongoing cycle of damage and remediation which has huge impacts on soil biological health and earthworm communities. For the UK site particularly, the benefits offered by any successful miscanthus crop production, simply by its perennial nature, would be immediate. Immediately the removal of continual soil working would allow soil biological communities to begin to return, enabling healthy functioning. The high levels of leaf litter drop overwinter, around 30% of total biomass, allows soil carbon levels to build up year on year, this along with the extensive root/rhizome system that develops over time means that this crop scores highly for carbon sequestration.

Significant gains from the perennial nature of the crop are also to be found in natural weed control. On areas of these heavy, often waterlogged soils in the East of England, there is a serious, and growing, problem with a perennial weed called Blackgrass *(Alopecurus myosuroides)*. Problems with this weed have been made worse by modern farming practices, autumn cropping, cessation of straw burning and a lack of effective chemical controls. Blackgrass seeds can persist for up to 10 years in the soil and are brought to the surface to germinate at each annual cultivation. *Miscanthus* can offer a great opportunity to cease this continual turnover for longer than the seeds can survive, and the rapid canopy development and continuous soil cover throughout the lifetime of the crop, which can easily last for 15 years, means that new populations of weeds have no chance to establish. This makes *miscanthus* the ideal choice for these very marginal arable soils; ideally a full crop cycle of *miscanthus* would greatly improve these areas, removing the weed burden, increasing soil organic matter

and improving carbon sequestration and biological functioning. These improved soils could then be returned to more typical arable production and the *miscanthus* moved to the next marginal area of the farm.
These benefits go beyond just the environment, they translate directly into on-farm benefits. After the first year or two, *miscanthus* should need no chemical weed control, fertilisers or pesticides, dramatically reducing the economic cost of producing a cash crop on these marginal lands. Machinery and resources are spared from these areas to further improve yields on the more profitable areas of the farm, with long term ten year contracts are available in the UK for *miscanthus* production with prices linked to inflation, farmers can be confident in planning their returns on investment.

Can *miscanthus* become a remedy for arable soil contamination in Poland?



by *Dr. Jacek Krzyżak*,
Institute for Ecology of Industrial Areas,
Poland

Marginal land in Poland

In Poland about 0.9 million hectares of arable have been turned into marginal land mainly due to unsustainable development of heavy industries and overexploitation of resources in the second half of the 20th century. The primary reason for excluding this land from food and feed production is potential contamination with heavy metals. In some areas, e.g. Upper and Lower Silesia, Lesser Poland, soil quality standards for metal concentrations are breached. In that context finding a proper solution for managing the use of the heavy metal contaminated (HMC) soils in a way that would generate environmental added value and provide economic benefits gains high importance.

Miscanthus - an alternative for contaminated land

One of the sites where the field experiments are carried out under the MISCOMAR project is located in the Upper Silesia, Southern Poland. Being once the country's heart of heavy industry and hard coal mining, the region is characterized by a mosaic of land use patterns. Industrial or post-industrial sites and waste deposits which are a legacy from the past industrial operations combine with a dense transport network and... agricultural fields. This is because farming has a long tradition in the region. However intensive industry activities from the past affected seriously the quality of the soils. They are either already highly contaminated or contain elevated amounts of potentially toxic elements such as Cd, Pb, As or phytotoxic Zn. Therefore food and feed production on these soils should be avoided. Despite that fact, they are permanently cultivated for crop production or hobby gardening due to a low awareness of the risk that heavy metals pose to human health and the habits of local communities. Production of energy crops such as *miscanthus* may be not only an alternative for a safe use of the contaminated arable land but an opportunity for the region.

Using *miscanthus* as the focus crop, the MISCOMAR project will develop model concepts for energy crops production with maximized environmental and economic benefits at a farm and landscape scale. These concepts will inform policy makers, farmers and a broader public about the potential of *miscanthus* for utilisation and environmental restoration of contaminated land. Further these concepts will contribute to an increased acceptance of *miscanthus* by environmental bodies, especially in functional areas such as water protection zones or intensive arable areas. Also recommendations will allow farmers in marginal and contaminated land areas to diversify and secure incomes. Food and feed produced on heavy metal contaminated soils often fails to reach minimum quality thresholds and cannot be sold. Therefore MISCOMAR will propose an alternative to the farmers: biomass production which could provide economic returns on otherwise under-utilised lands. However, the commercial and environmental viability of the alternative can only be determined when the quality and chemical composition of both the feed-stocks produced and changes to the soil itself are recognised. MISCOMAR will address both of these issues. The project will provide the answer on the suitability of the biomass produced on heavy metal contaminated soils for energy production together with the understanding of the potential for soil remediation.

Miscanthus as a key crop to cope with the challenges in the German biogas sector


by *Andreas Kiesel* and *Prof. Iris Lewandowski*, University of Hohenheim, Biobased Products and Energy Crops Department, Germany

Bio-mass and bio-biogas: The challenges

In Germany, the Renewable Energy Act (EEG) has led to rapid growth in the biogas sector by offering feed-in tariffs for electricity guaranteed for 20 years. In 2012, there were more than 7500 biogas plants in operation; however, amendments to the EEG in 2012 and 2014 brought about tough cuts in these feed-in tariffs which resulted in a slowing down of further development in the biogas sector. Today, more than 8000 biogas plants are in operation and 1.45 million ha arable land are used for biogas crop production, of which approx. 1 million ha are maize production.

In recent years, most biogas plants have been operated at a maximum capacity for 24h per day and produced so-called base load power. The value of this base load power collapsed, due to the increasing power production from renewables and the construction of the EEG allocation. The reason for this is that the EEG allocation is calculated as the difference between the electricity price at the European Energy Exchange and the feed-in tariffs. Sometimes this even led to the situation that the electricity price became negative, for example due to high power production from non-storable renewables, such as wind and photovoltaic (PV), during times of low demand, e.g. public holidays. Since power from biogas is much more expensive than from the competing renewables wind and PV, the base load power production from biogas has no future and may only be viable for very small, manure-only plants, provided that subsidies are further granted for such plants.

For the future, the feed-in tariffs for base load power are expected to be abolished or further decreased. This means that biogas plant owners need to revitalize their business model to enable a profitable plant operation after the period of their guaranteed feed-in tariffs. A very promising business model is to provide system services or to produce biomethane, which can be used as transport fuel or injected into the natural gas grid. The provision of system services includes all kinds of positive and negative peak load and also the storage of oversupply of wind and PV power. Multiple technologies are currently developed and already implemented in the biogas sector to enable demand-driven power production and storage (e.g. biological power-to-gas, two-stage high pressure fermentation, injection of sugar beet pulp). However, the biogas sector will have to face keen competition with other energy carriers and therefore needs producing more cost effectively.

Improving cost efficiency

The most important cost-factor for biogas plant operators is generally the price of substrates, which can often exceed 50% of the total costs for plant operation. Reducing substrate costs is therefore key to increasing the competitiveness of the biogas sector. Currently, energy crops deliver the largest proportion of the biogas produced with silage maize playing a dominant role due to well established crop production and easy handling in the digester. However, as an annual crop, maize needs to be established each year which is costly due to purchase of seeds, fertilizers, pesticides and required field work. Replacing (partly) silage maize by a perennial crop could offer economic and environmental benefits, especially on challenging soils e.g. with a high clay content. The annual inputs for the cultivation of the perennial *miscanthus* are low, but a successful establishment is required in the first year to achieve a highly productive and competitive crop. After successful establishment, the only field operations required are harvest and, in the case of biogas utilization, application of digestate. Such extensive crop management and a very high yield potential can help reduce the substrate costs and increase the economic feasibility of biogas plants. The anaerobic digestion of the fibrous *miscanthus* biomass is more challenging than in the case of maize and requires additional pretreatment of the biomass. However, sufficient pretreatment technologies, which were mostly developed for digestion of even more challenging residues, are already available and becoming state-of-the-art. *Miscanthus* seems to tolerate green harvest in late October and also first results for ensiling the biomass are promising. Further research is required to identify the long-term performance of green-harvested *miscanthus*, to establish a potential harvest window and to optimize the ensiling.

Both, the environment and the farmer would benefit from shifting the cultivation of maize for biogas to *miscanthus*. Low input requirements can help half the substrate costs. They can also minimize the environmental impact of the crop production, while maintaining a gas yield level comparable to maize.

How MISCOMAR can help?

The MISCOMAR project is another milestone in establishing *miscanthus* as a biogas crop, since it is aiming a reduction of the establishment costs of *miscanthus* plantations and demonstrating feasibility on a large scale. The three novel *miscanthus* genotypes and the standard commercial variety *M.* x *giganteus* are tested for biogas production, while monitoring the environmental impacts. Compared to *M.* x *giganteus*, the novel genotypes offer the potential to further decrease costs: first, by reducing the establishment costs due to seed-based propagation and second, by less challenging processing in biogas plants, the results of a less lignified biomass. Both represent an important step forward in the exploitation of *miscanthus* as biogas crop.

Economy, environment and marginal land

From an economic and environmental point of view, the cultivation of maize should be shifted into *miscanthus*, especially on challenging and marginal soils or sites where maize cultivation has a high environmental impact, e.g. drained peatland. On such soils maize cultivation is difficult and not always profitable in some years, e.g. due to very short periods available for soil preparation and sowing. Such sites often need proportionally higher management efforts and often maximum yield potential is not achieved, e.g. because of delayed sowing. By using *miscanthus*, farmers have a reliable yield from such challenging sites and can reduce their management efforts and impacts. This helps not only producing biogas more profitably, but also increasing the overall profitability of farms.

MISCOMAR: progress so far

POLAND

Field trial in Poland - Bytom site

Four novel *miscanthus* hybrids were planted along with the commercial standard *M.* x *giganteus* at the test site in Bytom, Upper Silesia. They were planted in replicated blocks, three of each genotype. During the first growing season plants growth and acclimatization to the heavy metal polluted soil were observed. At the end of the growing season all tested genotypes seemed to be well acclimatized, both to Polish climate and the contaminated environment. Unfortunately, at the beginning of the second growing season only two of the novel hybrids started regrow. The main reason was heavy frost and lack of snow cover in the turn of the year. Plant material was collected twice, at the end of the growing season in autumn and consequently before spring, to compare among others such parameter as heavy metal uptake. A lower content of heavy metals was found in all seed-based *miscanthus* hybrids in comparison to the standard *M. x giganteus*. Biomass yield results show that novel hybrids grow much faster than *M. x giganteus*, thus the yield can be obtained faster and it can be

Soil core sampling in Poland

higher. Two hybrids which have not survived the first winter were replaced by new, more frost resistant ones.

GERMANY

A field trial with 3 novel *miscanthus* genotypes and the standard cultivar *M.* x *giganteus* was established at the research station Unterer Lindenhof in South-West Germany. The field trial was established on an area of approx. 1 ha using commercially available technology to prove the technological readiness of *miscanthus* production. The standard cultivar *M.* x *giganteus* was propagated via rhizomes and the plantlets of the seed-propagated novel genotypes were planted using a conventional planter and covered by biodegradable mulch-film. The weed control in the establishment period was performed by using commercially available herbicides. First harvest was performed in autumn 2016 and spring 2017 and yields were recorded. Currently, biomass samples are being

Covereing the plantlets with biodegradable mulch-film

analysed in the laboratory. The laboratory analysis includes parameters which are crucial for combustion and anaerobic digestion.

UNITED KINDOM

Soil sampling

With the aid of all partners, baseline soil core sampling was carried out across all three sites co-ordinated by the UK team. This involved coring all individual plots down to 1 m depth, where possible, or down to the underlying gravel layer in the case of Germany. These soil cores were milled to remove stones and assessed for texture, soil density and water holding capacity before being archived at IBERS in the UK. Sub-samples from the top 60 cm (two layers, 0-30 cm and 30-60 cm) were taken from these and sent to both Poland and Germany to be analysed for nutrients (UHOH, Germany) and heavy metal content (IETU, Poland). A full report of the results has been prepared by IBERS and shared across the partners. Great differences were found across the sites with their marginality for agriculture reflected, for Poland the heavy metal contamination was clearly reflected in the soil analysis results, there being 20 times as much lead and zinc as in the other sites and 10 times as much cadmium. The nutrient depletion of the UK site was clearly shown by the results of the soil analysis. Compared to the other two sites, the UK sites showed extremely low potassium and phosphate contents. Similarly the heavy nature of the soils at the German site were captured well with the texture analysis results dominated by the high clay content.

UK site fieldwork

For the UK MISCOMAR site, planted in Lincolnshire, there were three novel *miscanthus* hybrids planted along with the commercial standard, *M.* x *giganteus*. These were planted in replicated strips with three of each genotype. Yield comparisons are being made between the new hybrids, which were planted using seed based material and novel mulch films, and *M. x giganteus* planted from clonal rhizome. Material from these plots was harvested twice from areas at either end of the strips, first at the end of the growing season in autumn and again in the following spring after ripening of the above ground material. This contrast between harvesting times is to determine differences in biomass yield and composition between the two dates, this may be an important factor in the fuel quality of the biomass produced and may not be consistent between the different hybrids. Knowledge gained here will be extremely important in providing management recommendations to farmers and end-users.

Plot in the United Kindom

Project Facts Sheet

Project acronym:	MISCOMAR
Project full title:	Miscanthus biomass options for contaminated and marginal land: quality, quantity and soil interactions
Project start date:	1st of May 2016
Duration of the project:	36 months
Project website:	www.miscomar.eu

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