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From Project Coordinator: Welcome to MISCOMAR+ Project

Dr Elaine Jensen
Co-ordinator of the project, Aberystwyth University, United Kingdom

Dear Readers,

Welcome to the 1st issue of the MISCOMAR+ Newsletter. Like others, we have experienced some challenges during this difficult time of COVID. Many activities have proceeded as planned, but others not quite. We are getting back on track with everything and now in a position to tell you about our project and report on the first two years of activities.

About MISCOMAR+

MISCOMAR+ is a follow-on project from MISCOMAR, which ran from 2016-2019. Both projects were funded for three-years under the flag of the Era-Net Cofund FACCE SURPLUS - Joint Programming Initiative on Agriculture, Food Security and Climate Change (FACCE-JPI).

The aim of the original MISCOMAR project was to determine the technical potential of novel *Miscanthus* hybrids on marginal and contaminated land (MaCL) and any resulting changes in soil health and structure. This project also investigated valorisation options for such biomass and promoted the integration of *Miscanthus* into existing farming systems for positive environmental and economic value. We identified hybrids that performed well on the different sites but found that **initial crop establishment is key**. As a continuation from this work, MISCOMAR+ therefore focuses on robust agronomies for crop establishment on challenging MaCL to enable intensive but sustainable biomass production. This project also allows a longer-term assessment of yield and soil quality changes from the trials established in the first project in 2016. We are also widening the valorisation options for the circular bioeconomy. MISCOMAR+ industrial and academic partners comprise *Miscanthus* breeders, agronomists, physiologists, biomass fractionation experts, remediation specialists, and conversion engineers in the UK, Germany, and Poland.

Test sites

In the original MISCOMAR project we investigated three trial sites: former intensively farmed and now nutrient depleted and waterlogged land in Lincolnshire (UK), high stone content soils in Unterer Lindenhof (Germany), and heavy metal contaminated arable land in Bytom (Poland). In MISCOMAR+ we maintain the exisiting sites and add three establishment trials, two are near the existing trials in Germany and Poland, and a third on a lignite mine near Cottbus (Germany).

Project Team

MISCOMAR+ is implemented by an international consortium of 4 academic institutes:

- **Institute of Biological, Environmental and Rural Sciences (IBERS) at Aberystwyth University, United Kingdom,**
- **University of Hohenheim, Biobased Products and Energy Crops Department (UHOH), Germany,**
- **Institute for Ecology of Industrial Areas (IETU), Poland,**
- **Research and Innovation Centre-ProAkademia (CBI), Poland.**

IBERS: Dr. Elaine Jensen (Co-ordinator) and (until Sept 2021) Prof. John Clifton-Brown are *Miscanthus* specialists and hosts to the largest collection of *Miscanthus* germplasm in Europe. IBERS provide overall project co-ordination as well as germplasm from their breeding programme, supported by **Terravesta Ltd**, who are responsible for maintaining the field trial in Lincoln. Terravesta Ltd will also be showcasing economic opportunities with *Miscanthus* through field open days.

UHOH: Dr. Andreas Kiesel and Ph.D. student Eva Lewin, in the Department of Biobased Products and Energy Crops, are responsible for existing trials at UHOH and field testing/monitoring establishment methods in Germany, as well as various environmental and socio-economic assessments of different value chains (i.e. paper production, gasification, and building materials). UHOH also run a land reversion trial to assess the impact of long-term miscanthus on soil fertility compared with annual maize. For the field trial on industrially damaged land, UHOH are assisted by Mr Uwe Kühn and Mrs Carmen Retzela, at **Gießereitechnik Kühn (GTK)**. GTK will also be showcasing economic opportunities with *Miscanthus* through field open days.

IETU: Drs. Jacek Krzyżak and Szymon Rusinowski in the Environmental Remediation research group work with Institute Director Prof. Marta Pogrzeba to continue the existing Polish field trial and new establishment methods.

CBI: Dr Marcin Siedlecki coordinates the investigation of the fate of trace elements after the thermochemical conversion of Miscanthus grown on contaminated soils. CBI also contribute to dissemination activities through a workshop for parties interested in the exploitation of marginal land and the valorisation of project results.

Please contact us if you need more information. I encourage you to follow our advancements on our web site www.miscomar.eu.

Miscanthus cultivation on heavy metal contaminated farmland - 7 years of experience

Prof. Marta Pogrzeba,
Dr Jacek Krzyżak,
Institute for Ecology
of Industrial Areas (IETU),
Poland

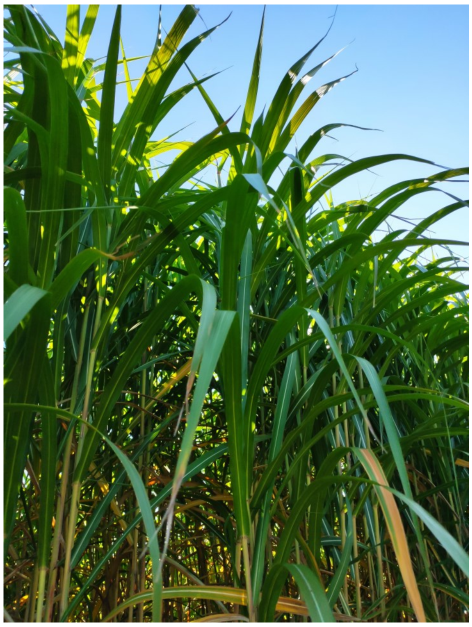
Miscanthus at Polish tests site.

The experimental *Miscanthus* plantation on heavy metal contaminated soil in Bytom, Poland, was established as part of the MISCOMAR project (2016-2019). Contamination of the soil with cadmium, lead and zinc was caused by the deposition of metal oxides emitted in the past by the nearby zinc and lead smelter. Heavy metal concentration of the agricultural soils in this region exceeds the permissible standards by several times.

Four *Miscanthus* seed-based genotypes (GNT1, GNT3, GNT34, GNT41) and rhizome-based TV1 (similar to Miscanthus x giganteus) were planted in 2016. Due to severe frosts and a snowless winter, GNT1 and GNT3 did not regrow after the first winter and were replaced by GNT5 and GNT14 in 2017. The replacement genotypes (GNT5 and GNT14), as well as GNT34, GNT41, and TV1, showed high adaptation both to growth on heavy metal contaminated soils and to climatic conditions in Poland. Over 80 % of all these genotypes survived into the second growing season. In the following growing seasons, photosynthesis and phenotypic measurements were carried out and the biomass was harvested in autumn (green cut) and spring (brown cut).

The seven years of field trials of *Miscanthus* biomass production on heavy metal contaminated land in Poland have shown that the yield potential of seed-based genotypes can be comparable, and even higher, than that of rhizome-based *Miscanthus x giganteus* - like hybrid, TV1. Our results showed that both all genotypes had very low uptake of lead, cadmium, and zinc in the aboveground biomass but higher concentrations of the analyzed heavy metals in the roots. These observations indicate that they are suitable for stabilizing heavy metals in the soil and the dense system of roots and rhizomes reduces both wind and water erosion of the soil. It was also shown that the presence of heavy metals in the soil, at least at these concentrations, does not affect plant growth, physiological parameters, or biomass yield. In addition, metal uptake of seed-based genotypes was found to be significantly lower than the rhizome-based *M. x giganteus* - like TV1.

Consistent research and field measurements suggest that *Miscanthus* is a crop ideally suited for cultivation in soils contaminated with heavy metals. Gasification tests conducted as part of the project have shown that this biomass is a good source of energy and that heavy metals do not re-enter the environment when the gas is combusted in a gas engine. An interesting part of our research in the near future will be to evaluate the long-term effects of *Miscanthus* cultivation on soil quality. To do this, soil samples will be taken within the plantation at the end of the project and analysed for heavy metal concentration, organic matter, soil organic carbon, and soil fertility.



Miscanthus at Polish tests site.

Novel agronomies for marginal land


Dr Andreas Kiesel,
Eva Lewin,
University of Hohenheim,
Germany

The perennial nature of *Miscanthus* makes it an interesting candidate for cultivation on marginal lands. Production on these lands would allow an expansion of biomass production in Europe without increasing competition for other land use options. *Miscanthus* must not be replanted each year and requires weed control only in the establishment period. After successful establishment the only requirement is annual harvesting. The high nutrient and water use efficiency and low input requirements make *Miscanthus* suitable for sites where conditions are often growth limiting, resulting in non-profitable yields for many other crops. Successful production of *Miscanthus* is however contingent on successful establishment. Losses after planting or over the first winter must be mitigated to avoid costly replanting. Successful establishment is characterized by low mortality and rapid growth of the plants to achieve high yields early in the plantation period.

Treatment	Description	Year of planting
Early and late planting dates	Separate plantings in mid and late May to determine impacts of planting date	2021
Plastic mulch	A thin biodegradable plastic film was applied over newly planted *Miscanthus*. This film increases the temperature and keeps in moisture.	2021, 2022
Miscanthus mulch	An approximately 5 cm layer of *Miscanthus* mulch that may prevent evaporation and provide a fertilization effect	2021, 2022
Mycorrhiza	Symbiotic soil fungi that may impart benefits to *Miscanthus* root growth (through nutrient and moisture acquisition)	2021, 2022—only at Reichwalde
Fertilizer	60kg/ha to compensate for low nitrogen at both sites	2022
Fertilizer + miscanthus mulch	60kg/ha nitrogen to counter potential nitrogen immobilisation seen under *Miscanthus* mulch in 2021	2022

Table 1) Treatments tested and the reasoning behind them.

As part of MISCOMAR+ establishment field trials were set up at two sites in Germany, with *Miscanthus* stands planted in 2021 and 2022. One set of field trials was established at Ihinger Hof in Southern Germany, near the University of Hohenheim, on a shallow, stony soil. The second set of trials was on land adjacent to the Reichwalde Coal Mine in Saxony, eastern Germany, on sandy soil with a high stone content and very low soil nutrients. Table 1 shows the treatments tested and the reasoning behind them.

In 2021 four genotypes were trialled; the standard commercial genotype *Miscanthus* x *giganteus*, and three novel seed-based genotypes GNT10, GNT43, and SYN55. At all sites GNT43 performed best, producing the tallest plants and the most biomass. At all sites SYN55 was the worst performing hybrid. All plants were grown from seed in the greenhouse prior to planting, and thus study showed that suitable planting material can be produced in the greenhouse from novel hybrids. At Ihinger Hof plants of some genotypes approached 2 m in height at the end of the first growing season. At Reichwalde plants did not establish as successfully and plants were in general much smaller. The use of plastic mulch resulted in plants of a similar size to the control but a large number of plants died during early establishment due to excessive heat after planting. Miscanthus mulch had a positive effect in the early season, as very few plants died in this period, but plants in this treatment did not grow as vigorously as the control, likely due to nitrogen shortage caused by immobilisation. Immobilisation occurs when soil microbes draw nitrogen

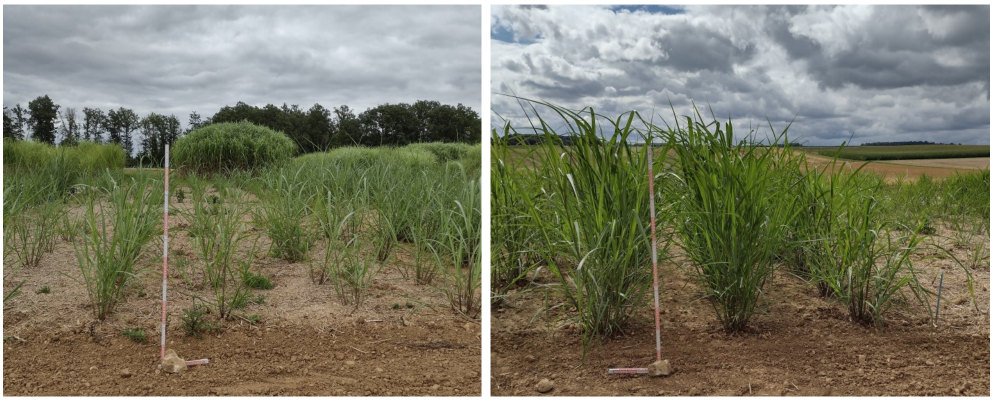


Figure a) GNT43 under miscanthus mulch (left) and in the control (right) on August 18th 2021 at Ihinger Hof. The measuring stick in this picture is 1m high. The negative effect of miscanthus mulch on the growth of GNT43 is clearly visible.

Figure b) GNT10, Miscanthus x giganteus and SYN55 photographed on August 12th 2022 at Ihinger Hof. In this 1 year old Miscanthus stand a clear difference in drought tolerance is visible. Despite low rainfall in July and August, GNT10 plants are still green and have not begun to lose their leaves like Miscanthus x giganteus has.

Figure c) Newly established Miscanthus at Ihinger Hof on August 17th 2022. Plants established under plastic mulch are much larger and have more stems than plants under other treatments.

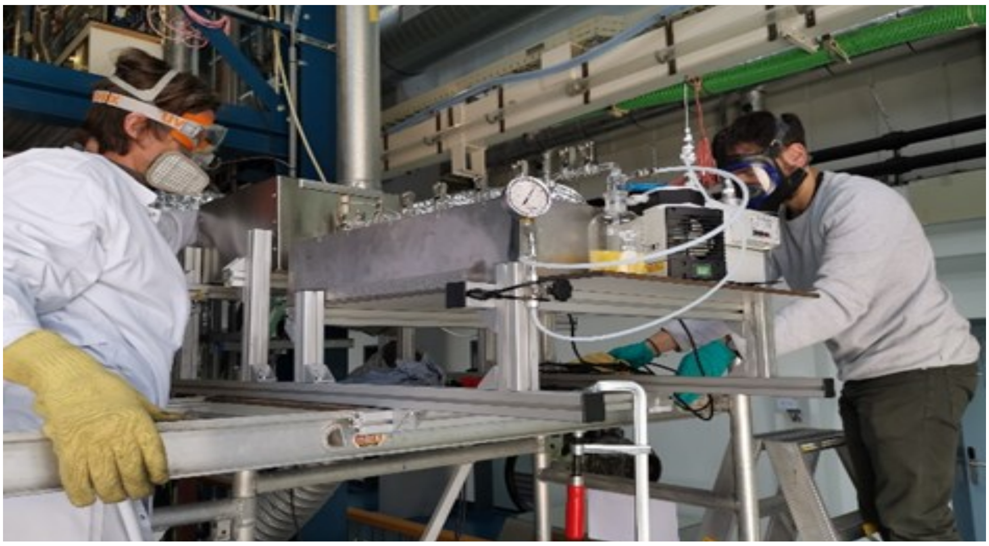
from the soil to help break down residues with a high C:N ratio. In 2022 monitoring of stands planted in 2021 continued. Genotype GNT10 showed superior drought tolerance, remaining green during the dry July and August period (Figure b) while *Miscanthus* x *giganteus* began to lose biomass due to water stress.

In 2022 plants were established at both sites either at the end of April (Ihinger Hof) or the first week of May (Reichwalde). In contrast to 2021 plastic mulch had a large positive effect on plants, resulting in larger, taller plants compared to the control. During the dry summer period, specifically in July and August, the *Miscanthus* mulch treatment was effective in maintaining soil moisture: the soil in this treatment remained moist even during the very dry summer period in 2022.

Miscanthus from contaminated land: a source of biomass for energy experience

Dr Marcin Siedlecki,
Research and Innovation CentreProAkademia (CBI), Poland

One of the main current challenges for our society is the sustainable replacement of non-renewable fossil fuel derived energy sources that can be stored and made available when needed. Perennial biomass feedstock such as *Miscanthus* can fulfill this requirement. *Miscanthus* can be cultivated on less productive or even polluted lands, avoiding competition with food production, and providing an annual harvest and thus annual income for the grower. Harvested Miscanthus can be stored (pelletized or otherwise) for later use, making it a controllable source of primary energy contributing to the transformation away from fossil energy sources. Ideally, cultivated *Miscanthus* should be used locally, to avoid long transportation distances. For local power generation at small to medium scale a gas engine can be used, requiring a gaseous fuel. Here a gasification process comes into picture. Depending on the technology used, a low to medium (4-12 MJ nm-3) calorific value gas can be produced. An important advantage of applying gasification technology is the possibility to apply staged gas cleaning and upgrading for fuels containing trace elements from heavy metal contamination. This not only allows the control of gas quality and (re) emission of harmful components back into the environment, but also creates a pathway for the separation and recovery of these potentially useful elements.



Handling the sampling line during one of the gasification tests

In the MISCOMAR+ project gasification experiments with two types of Miscanthus blends cultivated on the contaminated marginal lands in the Bytom area (Silesia, Poland) and harvested by IETU were performed by the Research and Innovation Center Pro-Akademia in cooperation with Delft University of Technology (the Netherlands) on their Bubbling Fluidized Bed Steam Reformer. Initial analysis of the results shows that most of the zinc, lead and cadmium present in *Miscanthus* were retained in the bottom ash. This is a promising result, as it means that the heavy metals will not be reintroduced into the environment when the gas is combusted in a gas engine. Meanwhile, char (the carbonaceous part of the bottom ash) is being assessed as a soil improver, and should therefore not contain an excessive amount of contaminants. Results so far suggest that the heavy metal content of char falls within the limits prescribed by the law. Nonetheless, further research in the MISCOMAR+ project on the recovery of these heavy metals from char is in progress. More results coming soon!

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Project Facts Sheet

Project acronym:	MISCOMAR+
Project full title:	Miscanthus for Contaminated and Marginal Lands PLUS
Project start date:	1st of May 2020
Duration of the project:	36 month
Project website:	www.miscomar.eu

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Project Founded by

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