PROJECT PERIODIC REPORT

Grant Agreement number: 289159

Project acronym: OPTIMISC

Project title: Optimizing *Miscanthus* Biomass Production

Funding Scheme: FP7-CP-TP

Date of latest version of Annex I against which the assessment will be made: 5.10.2015

Periodic report: **1st** ☐ **2nd** ☐ **3rd** ☐ **4th** ■

Period covered: **from** 01.03.2015 **to** 31.03.2016

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Declaration by the scientific representative of the project coordinator

I, as scientific representative of the coordinator of this project and in line with the obligations as stated in Article II.2.3 of the Grant Agreement declare that:

- The attached periodic report represents an accurate description of the work carried out in this project for this reporting period;
- The project (tick as appropriate):

  ■ has fully achieved its objectives and technical goals for the period;

  ☐ has achieved most of its objectives and technical goals for the period with relatively minor deviations.

  ☐ has failed to achieve critical objectives and/or is not at all on schedule.

- The public website, if applicable

  ■ is up to date

  ☐ is not up to date

- To my best knowledge, the financial statements which are being submitted as part of this report are in line with the actual work carried out and are consistent with the report on the resources used for the project (section 3.4) and if applicable with the certificate on financial statement.
- All beneficiaries, in particular non-profit public bodies, secondary and higher education establishments, research organisations and SMEs, have declared to have verified their legal status. Any changes have been reported under section 3.2.3 (Project Management) in accordance with Article II.3.f of the Grant Agreement.

Name of scientific representative of the Coordinator: Prof. Iris Lewandowski

Date: 31.05.2016

Publishable summary

1.1. A summary description of project context and objectives

Miscanthus is a leading species for production of lignocellulosic feedstocks because it utilises both C4 photosynthesis and a perennial rhizome system which results in high output:input energy ratios. Currently only a single clone, *M.* × *giganteus* is commercially cultivated in Europe. Research over the past 20 years has demonstrated that breeding and selection of *Miscanthus* types are needed to extend the production areas and diversify the bioproduct chains.

The main objective of OPTIMISC is to optimize *Miscanthus* bioenergy and bioproduct chains by trialling elite germplasm types over a range of sites across central Europe, Ukraine, Russia and China. In doing so, the key traits that currently limit the potential of *Miscanthus* are analysed, high-value bioproducts are identified and the combined results are modelled to provide recommendations to policymakers, growers and industry. The outcomes of the project include screened germplasm and solutions to several key bottlenecks in *Miscanthus* cultivation.

The OPTIMISC consortium consists of 12 partners within and outside Europe. The project activities are divided into eight work packages (WPs) with WP1 fully dedicated to the management and coordination of the activities to ensure successful accomplishment of the project's goals.

Partners involved in WP2 were responsible for the initial selection, propagation and distribution of *Miscanthus* germplasm for experiments in WP3 and 4. In the fourth period, further work was carried out on increasing the efficiency of the propagation rate from *in vitro* tillering using different combinations of phytohormones in the culture media.

In WP3 a suite of experiments were conducted to characterise the abiotic stresses: drought, salinity, cold and freezing. Useful diversity was found for further breeding. In the WP4 multilocation trials growth parameters, yield and quality were determined in a wide range of environments.

In WP5 large-scale field trials in Germany, Ukraine and UK were used to develop commercial scale know how for establishment, harvesting and utilization of novel *Miscanthus* hybrids.

The WP6 objective was to identify high-yielding *Miscanthus* genotypes which produce biomass of excellent quality for different added-value uses and which are optimal for multiple plant-derived bioproducts.

Data gathered in WPs 4-6 have been integrated into the miscanthus production model Miscanfor to produce yield estimates spatially. Projected yields have been supplied as base data into several life-cycle analysis (LCA) models and other decision support tools to identify optimum *Miscanthus* production scenarios in varying environments (WP7).

Through the dissemination activities initiated in WP8, information on the project, project outcomes and recommendations for specific user groups are communicated to a wide range of stakeholders.

1.2. A description of the work performed since the beginning of the project and the main results achieved so far

Selection of the germplasm for the experiments in WP3-6 was made in 2012. By 2013, about 100 *Miscanthus* genotypes had been transferred to *in vitro* culture. A subset of genotypes were selected for the WP4 multi-location trials and about 15,000 plants were planted in May 2013. Methods for *in vitro* work have been continuously improved throughout the project.

WP3 experiments aimed to screen wild and hybrid miscanthus germplasm for their tolerance to drought, salinity and low temperatures. A set of genotypes combing tolerance to both salt and drought stress were identified. For drought tolerance, water use efficiency and root development appear to be two important traits. For salt tolerance, ion exclusion mechanisms appear to confer stress tolerance. A next step would be to evaluate the yield performance of these genotypes and their progeny on marginal land sites. Useful diversity was also observed for spring chilling tolerance. Overwinter cold tolerance was assessed with artificial freezing tests to determine LT_{50}. Significant variations in LT_{50} were found in the 100 OPTIMISC selections; this information helps to project an extension to the geographic range for the crop using Miscanfor model.

The plot trials established at six locations in Europe, Russia and Turkey with 15 types of miscanthus showed large genotype x environment effects. Growth measurement protocols were standardised in 2013 and applied through 2014, 2015 at all sites as the plants in the plots matured. The elite hybrid OPM-6 showed the highest biomass production as an average across all sites.

In China seed from 36 wild accessions were planted in 2013 at two sites near Dongying with natural soil salinity variations. Different growth responses were observed over three years leading to recommended selections for further breeding. The effects of different planting and mowing regimes on miscanthus establishment in grassland and yields in the mixed grassland/miscanthus production systems were assessed in trials on marginal land in Germany.

Commercially relevant large-scale field trials were established in UK in 2012 and in Ukraine and Germany in 2013 using ‘seed to plug to field’ planting methods for the first time on this scale. Innovations were made to improve efficiencies along the production chain from field to furnace. An added value chain including chlorophyll extraction showed the potential for a ‘stay green’ population hybrid with more in season cutting tolerance than standard *M. x giganteus*.

In WP6 the quality of biomass from the WP4 trials was quantified and a range of biobased product chains were evaluated including biogas, saccharification and combustion. The interplay between cell wall composition of different genotypes harvested at different times on the different product types was studied, as well as how this is influenced by harvest regime, abiotic stresses and geographic location using the harvested material from the quality dedicated field trials (WP6), the multi-location trials (WP4) and the abiotic stress tests (WP3). Both a large genotypic variation in quality traits and a strong environment effect on genotype performance have been observed.

Harvesting model for optimization of biomass quality (WP7) has been developed. Samples of biomass from field trials at several sites were taken and analysed for quality and composition. The data collected were fed into harvesting model.

OPTIMISC’s website is updated on a regular basis and public newsletters are released (WP8). Over 30 dissemination activities directed at all stakeholder levels were carried out. OPTIMISC was presented at numerous scientific conferences, exhibition events and at the demonstration day in the UK. The project final conference took place in 2015. Ten articles have been published or accepted for publication in peer-reviewed scientific journals so far. Two special issues in the scientific journals on the topic have been initiated.

1.3. The expected final results and their potential impact and use

The final outcomes of the project include screened germplasm and knowledge providing solutions to key bottlenecks in *Miscanthus* cultivation. Data gathered in the OPTIMISC experiments enabled the development of the decision-support tool to identify optimum production scenarios. Recommendations have been provided to *Miscanthus* developers on appropriate genotype selection, propagation and processing methods to maximize the environmental, economic and social benefits of this bioenergy crop. Finally, the development of the full potential of *Miscanthus* through OPTIMISC will contribute to Europe's transition to a sustainable biobased economy.

The propagation of the plant material for the OPTIMISC experiments was based on *in vitro* culture techniques, rhizomes and seeds. The final outcomes of the WP on propagation (WP2) are improvement of tissue culture techniques relating to rooting of plants and the use of shoot tips in addition to nodal buds as the method of plant multiplication by direct *in vitro* tillering. Propagation methods have been compared and evaluated with regard to their practicability, efficiency and commercialization.

The main results of WP3 are the identification of traits that contribute to abiotic stress tolerance in *Miscanthus*, assessment of the genetic diversity of abiotic stress tolerance in a broad set of *Miscanthus* genotypes and selection of genotypes with favourable tolerance of abiotic stress. We identified genotypes that can be used for improved cultivation of miscanthus on marginal lands. In addition, several traits for various stresses were identified that can aid in the selection of new genotypes with favourable growth under adverse conditions, and can be used for efficient selection in breeding programs for improved stress tolerance in miscanthus.

The multi-location trials (WP4) allowed to identify elite high-yielding genotypes. Experimental agronomy trials for establishment of miscanthus in grasslands in Germany and screening trials for salinity tolerance in wild germplasm in China both help ensure the crop of the future can be grown on lower-grade land. Combining traits with climatic and edaphic factors in modelling contributes to the knowledge on appropriate selection of miscanthus genotypes for a range of good and marginal lands.

The main results of WP5 are the development of a full agronomic procedure for commercial-scale establishment of new *Miscanthus* hybrids, including planting, plant care and management, and improvement of harvest technologies and pelletizing options.

Important outcomes of WP6 are the identification of genotypes with superior performance for different aspects of biomass quality, ranging from biogas, bioethanol production or combustion to novel bioproducts. The scientific outcomes provide insights into the extent of exploitable variation in *Miscanthus* in cell wall composition and biomass quality parameters and how these traits are influenced by genotype, environment, harvest date and harvest regime (multiple cuttings).

The main final result of WP7 is the development of a harvesting model to optimize biomass quality and dry matter yield and to define the best harvesting time for each genotype to achieve optimal biomass quality for specific end uses. Based on life-cycle analysis (LCA) and cost assessment, the best performing *Miscanthus*-based value chains have been identified for the tested locations.

Dissemination work activities communicate the project outcomes to relevant stakeholders along the *Miscanthus* value chains, whereas linking of OPTIMISC information platform with the International *Miscanthus* Society's and French *Miscanthus* information websites strengthens the participation of SMEs and industry in *Miscanthus*-related projects, stimulates information flow and networking of *Miscanthus* stakeholders.

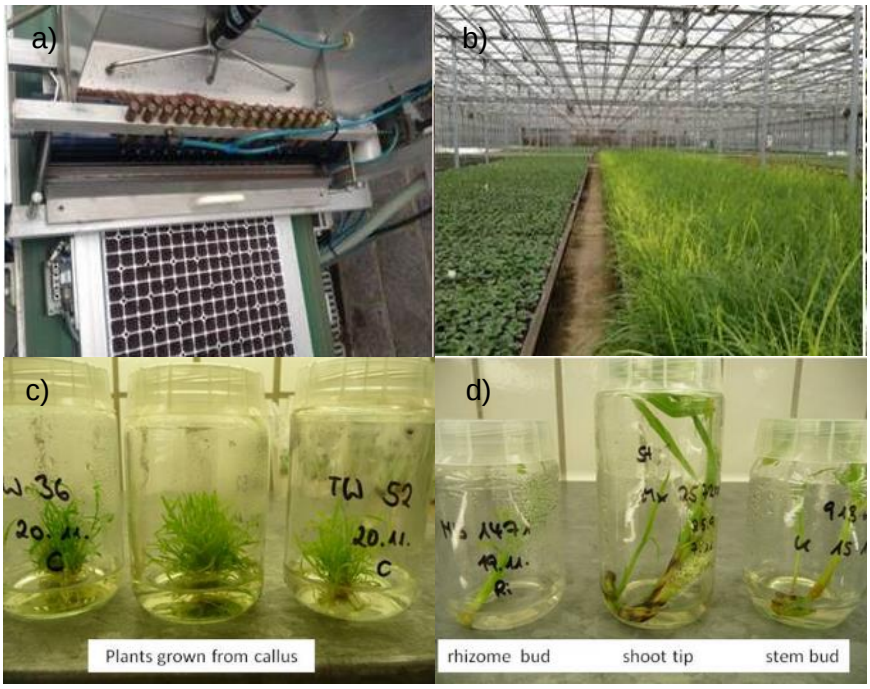
1.4. The address of the project public website/s

The two OPTIMISC websites provide information on the project's progress and news for researchers, *Miscanthus* stakeholders and the general public:

OPTIMISC project website: http://www.optimisc-project.eu

OPTIMISC public information platform: http://platform.optimisc-project.eu

1.5. Supplementary material to publishable summary

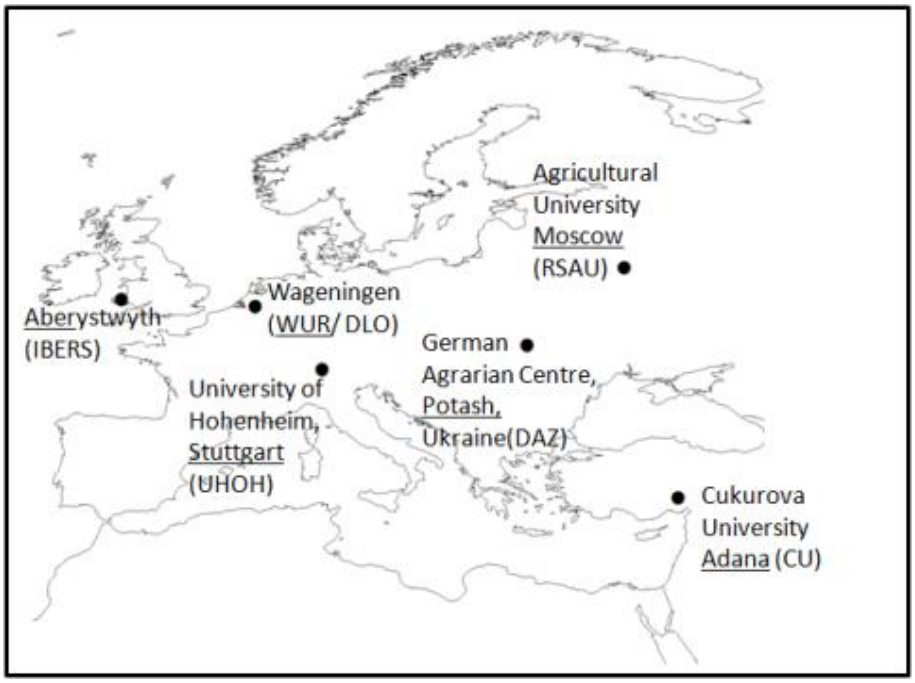


Different methods of *Miscanthus* propagation in OPTIMISC: (a) *Miscanthus* automatic seed planting and (b) plants grown from seeds in the UK; (c) plants grown from callus and (d) plants grown from rhizome/nodal buds at Schwarz, Germany.

Shoot development of *in vitro* plants depending on phytohormones: Less but long shoots for BAP as only phytohormone and more but mainly short shoots for the mixtures of phytohormones.

Location characteristics and previous land use of the six OPTIMISC field trials established in May 2012 (WP4).

Site No	Country	Location name	Latitude	Longitude	Altitude (m)	Previous land use
1	Turkey	Adana	37.00	35.00	27	arable
2	Germany	Stuttgart	48.74	8.93	463	arable
3	Ukraine	Potash	48.89	30.44	237	arable
4	Netherlands	Wageningen	51.59	5.39	10	horticultural
5	UK	Aberystwyth	52.43	-4.01	39	grassland
6	Russia	Moscow	55.00	37.00	140	arable



Location of the six OPTIMISC field trials with 15 miscanthus genotypes.

Long-term* annual and growing season (approximated by April to September) temperature (degrees C) and rainfall (mm) for the six sites.

Site Nr	Location name	Historical data years	Air Temperature, °C		Rainfall, mm	
			Annual	April to Sept	Annual	April to Sept
1	Adana	2000-2011	19.0	26.1	575.2	75.4
2	Stuttgart	1988-1999	9.8	16.4	725.4	378.8
3	Potash	2003-2012	8.9	18.5	537.2	300.2
4	Wageningen	2002-2012	10.3	15.8	826.4	376.2
5	Aberystwyth	1954-2000	9.7	13.8	1038.1	401.2
6	Moscow	1881-1980	4.1	14.8	644.0	347.0

WP4 field trial at Aberystwyth (UK) planted on former grassland. 29th September 2015.

WP4 field trial at Stuttgart (Germany). 2nd October 2015.

WP4 field trial at Adana (Turkey) 10th February 2016.

Field trial at Stuttgart (a) 10th September 2015 (b) 18th March 2015.

Harvest of OPM-111 (*Miscanthus* hybrid). OPTIMISC large-scale trial. March 2016.

Different size bailing (*M. x giganteus*) at harvest 2016. OPTIMISC large-scale trial.

Pellets of OPM-111 from Blankney Estate (UK) pellet press facility.

Tomasz Calikowski from the European Commission DG Research and Innovation giving a speech on EU-level initiatives for the bioeconomy during the plenary session on Tuesday, September 8.