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MELiSSA

Memorandum of Understanding

TOS-MCT/2002/3161/In/CL

Technical Note 76.1

Joint Progress Report to the Canadian Space Agency and the European Space Agency MELiSSA Program

For the Contract Period April 1, 2002 to June 30, 2002

Version 1

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Joint Report to the Canadian Space Agency and the European Space Agency MELiSSA Program
CSA Contract 9F007-010139/00/ST and ESA-MELiSSA MOU TOS-MCT/2002/3161/In/CL

Reporting Period July 1, 2002 to September 31, 2002

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Reporting Period July 1, 2002 to September 31, 2002

Including a Higher Plant Chamber in the MELiSSA Loop

Joint Progress Report to the Canadian Space Agency and the European Space Agency MELiSSA Program

For Work Completed Under Canadian Space Agency Contract 9F007-010139/00/ST and European Space Agency MELiSSA Memorandum of Understanding TOS-MCT/2002/3161/In/CL dated January 2002.

For the Period of April 1, 2002 to June 30, 2002

Section 1.0 – Report Summary

Work on this project is progressing well. Studies with batch trials are, for the most part, complete. At some point in the future it may be necessary to replicate basic CO_2 response studies under batch planting. This need is dependent upon the results obtained from future light and CO_2 response studies for the integrated planting of beet and lettuce. At present, experiments are being conducted with integrated and staged planting of two of the three MEliSSA pilot plant crops (beet and lettuce; not including wheat). Gas dynamic models, including stand responses to light intensity are being developed for the integrated and staged stand. Early results will be obtained in the Winter of 2003 and reported in the Spring of 2003.

Section 2.0 – Report on Milestones

Milestone 1.1: Development of Dynamic Carbon Exchange Models for Monocultures

This milestone has been completed and was reported in ESA TNs 50.1 and 50.2. As to be reported in an addendum to these technical notes (March, 2003) the methods used to collect data on stand response to CO_2 and ambient variations in light intensity are experimental. The data presented in TNs 50.1 and 50.2 were based on an 'open' chamber design, or more formally a hybrid of a compensating and a flow through method of collecting Net Carbon Exchange Rate (NCER) data. Further, the rectangular hyperbola function which was modified to allow for dynamic light compensation and saturation points associated with crop growth, was also experimental. Upon review of those methods and results we have concluded that the hybrid chambers be restricted to use as exposure chambers until technical improvements render them useful for NCER determination. The large sealed environment chambers which more routinely estimate NCER on a compensating basis are now being employed for assessing stand responses to light intensity. As such, the hybrid chambers will continue to be used for assessing yield (at

harvest), nutrient and water use responses under long term CO_2 enrichment, as exposure chambers. Work relating to NCER determinations will be conducted in the large sealed chambers designed specifically for this task. Experiments are now underway which yield light responses of integrated stands (mixed production of lettuce and beet in a staged fashion) to light variation. This method simplifies the rectangular hyperbola model since the light compensation (NCER=0) and saturation (NCER at a maximum) points of a staged stand with even age distributions lessens the need for an additional term allowing for dynamics in these variables due to stand development. As such, the light response curves developed and presented in TNs 50.1 and 50.2 are to be replaced with those collected under staged and integrated production. This is of direct relevance to integration of the MELiSSA loop. Following collection of these data, it may be possible to evaluate NCER responses of the batch or staged monoculture stand to light intensity. We will, however, continue with our investigations on integrated production as it is the most likely production scenario for the MEliSSA pilot plant.

Milestone 1.2: Assessment of the Degradation Efficiency of Inedible Biomass in Compartment I

This milestone is being completed in conjunction with EPAS (Belgium). Work continues on the assessment of degradation efficiency for the 3 MELiSSA Pilot Plant candidate crops. This milestone is progressing well and we hope that EPAS will present results at the ESA-MELiSSA annual meeting to be held in Claremont-Ferrand, FR. in May, 2003.

Milestone 1.3: Development of Carbon Exchange Models for the Integrated Canopy

This milestone commenced in May 2002. Two large full canopy chambers have been planted with four age classes of beet. This experiment aims at developing gas exchange data for the staged production scenario. Following the completion of this experiment with beet an inter-cropping experiment will be conducted with lettuce and beet in the same chamber. This future experiment will allow for the development of gas exchange models for the integrated canopy.

Milestone 1.4: Development of Steady State Models for the HPC

This milestone is on-going. All experiments conducted in the large full canopy chambers are being evaluated at nominal light and CO_2 conditions of 300-600 $\mu mol\ m^{-2}\ s^{-1}$ PPF (at canopy height) and 1000 $\mu L\ L^{-1}$ CO_2. Data will continue to be made available and updates will be provided at the ESA ESA-MELiSSA annual meeting to be held in Claremont-Ferrand, FR. in May, 2003.

Milestone 2.1: Integration of Steady State Models for All MELiSSA Compartments including the HPC

This milestone is being handled in conjunction with milestone 1.4. Some data were reported upon in TNs 53.2 and 53.3, particularly with regard to nutrient uptake and supply, water use and efficiency and carbon balance. No new data are available at the time of this report. Data will be made available at the completion of the current experiment outlined in Milestone 1.3

Milestones 3.1 – 3.3: Sizing of the HPC and the Development of Cultural and Atmospheric Management Strategies

These milestones are also on-going and progressing in tandem with integrated canopy trials outline above (Milestone 1.3). Data should be made available on schedule.

Milestones 4.1-5.1: Development of Control Algorithms of the HPC, Design of the HPC Compartment and Interface with Other Compartments

At the time of this report these milestones have not been commenced, with exception of, to our understanding, Mlestone 4.1. Results of simulated process modeling will be made available at the ESA ESA-MELiSSA annual meeting to be held in Claremont-Ferrand, FR. in May, 2003. All other milestones will be started pending the completion and/or sufficient receipt of data from previous milestones.

Appendix 1 – Summary of Milestones

1. **Steady State and Dynamic Modeling of the Higher Plant Chamber (HPC)** – The purpose of this objective is to collect data relevant to the dynamic and static modeling of the HPC, including harvest yield and partitioning, crop response (NCER, transpiration, nutrient uptake) to environment conditions (light and CO_2) and the degradation of inedible biomass in the fermentative compartment. The development of empirical models from the resulting data set will then be used to assess steady state of the loop including the HPC. (UoG, CF, EPAS)

2. **Integration of Steady State Models for All MELiSSA Compartments including the HPC** – This objective aims at assessing steady state of the MELiSSA loop including the HPC, with respect to CO_2, O_2, water, major nutrients (including those materials from the degradation of inedible biomass in the fermentative compartment). (CF, UoG)

3. **Sizing of the HPC and the Development of Cultural and Atmospheric Management Strategies** – From the data collected for various crops, particularly with respect to crop NCER responses to environment variables, management strategies for the stabilization of long and short term gas and water exchange dynamics will be established. Cultural management strategies for the production of candidate crops in a common atmosphere will also be established based on the same data (UoG, CF)**.**

4. **Development of Control Algorithms of the HPC –** The Higher Plant Compartment has to be elaborated and tested on a simulator before being transferred into the controller of the pilot process, as it has been done in the current MELISSA project for other compartments (ADERSA, Guelph)

5. **Design of the HPC Compartment and Interface with Other Compartments –** An HPC will be designed based on the results of the steady state and dynamic simulations, with particular emphasis on its interface of other compartments (UAB, EPAS, ADERSA, CF, UoG)

Appendix 2 – Summary of Schedule and Milestones

Deliverable	Forecasted Completion
0.0 Kick-Off meeting, appointment of PDF	Nov., 2001
1.1 Development of dynamic carbon exchange models for monocultures	Mar., 2002
1.2 Assess degradation efficiency of inedible biomass in compartment I	Dec., 2002
1.3 Development of carbon exchange models for the integrated canopy	Mar., 2003
1.4 Development of dynamic and steady state models for the HPC	Oct., 2003
2.1 Assessment of system level mass balance with respect to water, nutrients, gases and biomass	Jan., 2004
3.1 Development of models for atmospheric management of integrated canopies under staggered planting and photoperiod offset	Mar., 2004
3.2 Validation of models of mass dynamic for integrated canopies under staggered planting and photoperiod offset	Jun., 2004
3.3 Determination of the HPC size required for interfacing with the MELiSSA loop	Oct., 2004
4.1 Software of the simulated process written with Simulink® and Matlab® advanced languages	Oct., 2002
4.2 Model Based Predictive Control software written in C language	Jun., 2003
4.3 Specifications of the sensors and actuators	Oct., 2003
4.4 Implementation of the control in a PC by means of a DLL (Dynamic Link Library) directly built from the C language software, without any transcription of the C software into another automated language	May, 2004
5.1 Design of the Higher Plant Chamber for loop integration based on results of previous studies	Dec., 2004
Annual Report and Annual Review	April, 2002
Annual Report and Annual Review	April, 2003
Annual Report and Annual Review	April, 2004
Final Report	Mar. 31, 2005

Appendix 3 – Project Management Timeline

Public Works and Government Service Canada	**Contract Plan and Report Form**

Contract No. 9F007-010139/00/ST
Requisition No. 9F007-010139
File No. 009ST.9F007-010139
Contractor: University of Guelph, Controlled Environment Systems Research Facility

Task Description		**Task Duration**								
	11/01 – 03/02		04/02 – 09/02		10/02 – 03/03		04/03 – 09/03		10/03 – 03/04	04/(
1.1 Note 1										
1.2										
1.3										
1.4										
2.1										
3.1										
3.2										
3.3										
4.1										
4.2										
4.3										
4.4										
5.1										
Annual Report & Review										
Annual Report & Review										
Annual Report & Review										
Final Report										
Original Estimate		Note 1. Task 1.1 is reported upon in ESA TNs 50.1 and 50.2. Since these TNs are								
Completed		annual report under this contract, the first of the joint reports filed to ESA is the per								
In Progress		2002. An addendum to the original TNs 50.1 and 50.1 is currently under preparation								
Joint Activity		progress and reporting section for Milestone 1.1								
ADERSA/Guelph										
EPAS/Guelph										
Clermont-Ferrand/Guelph										
UAB/Guelph Activity*										