



D7.1.3 Demonstration Report

3rd Year Progress

CONTRIBUTING AUTHORS: Jos Balendonck, Erik van Os (WR), Burcu Yazici (SUEN), Miguel Gomes Santos (FCUP), Klara Löfkvist (RISE), Francisco S. Millán (RITEC).

REVIEWERS: José Boaventura (INESC TEC) | Tatiana Pinho (INESC TEC) | Susana Carvalho (FCUP) | Miguel Santos (FCUP)

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PROJECT COORDINATOR:

Dr. José Boaventura-Cunha

INESC TEC

R. Dr. Roberto Frias,

4200-465 Porto, Portugal

E-mail: jose.boaventura@inesctec.pt

PROJECT WEBSITE: www.agrinupes.eu

DOCUMENT CORRESPONDING AUTHOR:

Jos Balendonck

Wageningen Research

P.O. Box 644, 6700 AP Wageningen, The Netherlands

E-mail: jos.balendonck@wur.nl



Table of contents

Summary	5
1. Introduction	6
2. Demonstration plan and progress	7
Introduction	7
Plan for demonstration	8
Progress	8
3. Conclusion	10
Annexes	11
Annex 1: Summary of Case Study dissemination activities.....	11
Annex 2. Leaflets and posters	16
WIRE brochure	16
Poster 1 (PT).....	19
Poster 2 (PT).....	20
Poster 3 (PT).....	21
Poster 4 (PT).....	22
Poster 5 (NL).....	23
Poster 6 (NL).....	24
Annex 3. Minutes of UNG-meetings.....	25
Minutes UNG groups the Netherlands	25
Minutes UNG groups Sweden	27
Minutes UNG groups Portugal	28
Minutes UNG groups Turkey	30

List of abbreviations

AGRINUPES	Integrated monitoring and control of water, nutrients and plant protection products towards a sustainable agricultural sector
UNG(s)	User Network Group(s)
BMP	Best Management Practices

List of figures

Figure 1. Poster presentation during Water Event (2018).....	25
Figure 2. Presentation of poster and prototype NPK-sensor set-up at Water Event (2019).	26
Figure 3. Information and coffee at Sånnagården (March 29, 2019).	27
Figure 4. Information and guidance at Orevads (April 4, 2019).....	27
Figure 5. ‘Round table’ discussion with stakeholders during the Portuguese UNG Meeting (September 24, 2018).	28
Figure 6. Photos taken at the Thematic Workshop at Dushanbe (2019).	30
Figure 7. UNG meeting with local stakeholders in Konya.	31
Figure 8. UNG meeting with local stakeholders in Konya (2018).	31

List of tables

Table 1. Demonstration: Planning and Progress.	8
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Summary

One of the objectives of AGRINUPES is to undertake demonstration and communication activities in the case areas. This includes the exchange of experiences of good practices among partners and stakeholders related to the developed NPK and biosensors.

Demonstration, being a communication activity, is done in the case study work packages (WP3, WP4, WP5 and WP6). Work Package 7 (Task 7.1) focusses on the coordination of the overall process of demonstration and collects and finalises the overall reporting containing summary reports of demonstration, dissemination and external communication. Demonstration was expected to start from month 18 on, once working prototypes of sensors would have become available. This public Demonstration report describes the progress on the demonstration activities. It contains the collected minutes of User Network Groups (UNG) meetings and short summaries of individual Demonstration Reports and related dissemination activities in the case studies. It was an evolving document with milestones at M12 (D7.1.1), M24 (D7.1.2) and M45. This final report (D7.1.3) gives the status at the end of the project (M45).

In the Use Case areas Portugal, The Netherlands, Turkey and Sweden, User Network Groups have been set-up. Stakeholders have been informed about the targets of the AGRINUPES project, via national websites, group meetings, poster presentations, magazine articles, and international scientific conferences.

The prototype NPK-sensor have become available in the second year, and for Portugal and in The Netherlands it was demonstrated in 2019. Sweden did plan the presentations in early 2020, but due to the COVID-19 situation this had to be postponed. The final prototype NPK-sensor was tested by the end of 2020 but could not be demonstrated in one of the use case areas yet.

The prototype biosensor came available for application in laboratory situations as of beginning 2020. This prototype was tested both in Turkey and Sweden, but by the time it could be evaluated for real-world situations, COVID-19 restriction didn't allow for travel anymore. Therefore, the prototype biosensor could not be demonstrated to the Use Network Groups yet. Instead, real samples taken at the Konya basin were analysed at the EGE lab for evaluation.

All use cases have postponed final presentation of the sensors beyond the end of the project, and as soon as the COVID-19 restrictions allow for organizing group meetings in 2021.

1. Introduction

The AGRINUPES general objective is to undertake demonstration and communication activities in all case areas, including the exchange of experiences of good practices among partners and stakeholders. The Work Package 7 (WP7) focusses on this. It is coordinated by WUR and involves three tasks: Demonstration (T7.1), Dissemination (T7.2) and Communication (T7.3).

Demonstration, being a communication activity (see D7.4) is done in the case studies (WP3, WP4, WP5 and WP6) and as such its results are described in detail in the specific deliverables for these WPs. T7.1 focuses on the coordination of the overall process of demonstration and collects and finalises the overall reporting containing summary reports of demonstration, dissemination and external communication.

This public Demonstration Report (T7.1, D7.1) describes the progress on the demonstration activities. It contains the collected minutes of User Network Groups (UNG) meetings and summaries of Demonstration Reports and all related dissemination activities in the case studies. It is an evolving document (3 versions: 1,2 and 3) with milestones at M12, M36 and M45. Demonstration was expected to start from month 18 on (once working prototypes of sensors would become available). The other two tasks (T7.2 and T7.3) run during the whole project execution (M1-M45).

In the second year the first prototypes for the NPK-sensor and biosensors have become available only to a much later moment than planned. As such, the second-year report (D7.1.2) was issued much later than planned and reports the status of the project demonstrations until the first quarter of 2020. All activities for demonstration of the final sensors were postponed until 2020 and are reported in this final document (D7.1.3) at the project ending (M45).

2. Demonstration plan and progress

Introduction

According to the planned in the project proposal, in all partners case areas, bi-annual UNG meetings will be organised for targeted stakeholder consultation to inform about the progress and to get feedback from the end-users and potential resellers for the developed sensors and tools. At least once for every case study, an info-day or seminar will be organised locally at the demonstration site for end-user feedback and dissemination and exploitation purposes of demonstration results. The minutes of these meetings will be shared among all partners. These info-days are open to a wide public as for instance for growers, extension workers and technical suppliers, during which they can visit the demo-facilities and attend workshops.

The targeted audiences for the case study areas are:

- **End-users:** These are the growers, advisory services and water authorities using the monitoring equipment, sensors and tools. They want to use the sensors in order to either enhance their production or quality of the crop, to minimize their use of inputs (water, nutrients, PPPs) or to be able to comply with existing legislation. They can be reached for instance through the User Network Groups, or other networks.
- **Suppliers:** These are potential resellers of the sensors and tools to be developed. They want to know how sensors/tools work, can be applied and to which markets they could be sold.
- **National or European (financing) bodies:** These are in general policy-based bodies that are interested to know that new monitoring technologies become available that can support the goals for legislation (emission reduction).
- **Scientific community:** All bodies dealing with research and education in the field of monitoring and control for agriculture and water related issues. These will be mostly interested to know how sensors work, can be applied also in other (newer) applications.
- **Public Audience:** These are all other stakeholders interested in any way in sensors and tools for agricultural practices.

The case studies will use the following communication channels:

- **User Network Group (UNG) meetings:** All case areas partners will organise on bi-annual scale stakeholder consultation meetings to inform UNG upon the progress and to get feedback from the end-users. Minutes of the meetings (as well in English) will be shared among all partners.
- **Info-days or seminars:** local (open) general meetings are organised for end-user feedback and dissemination (and exploitation) of demonstration results (preferably every year, but at least) once at every case study. These local seminars are for growers, extension workers and technical suppliers. Under guidance of the case study leader, users will be invited to visit the demo-facilities and attend workshops.
- **Website:** Case studies will maintain a website which will be used as gateway to the local community. The website will communicate in the local language. All activities will be announced through this website, as well as the newsletters will be distributed.
- **Publications:** Partners will disseminate results through articles in local magazines.

While using these communication channels, the case studies will use following communication means:

- **Press Releases:** To inform a wide group of people, a press release about upcoming events (annual seminars) and achieved milestones will be issued on a national scale by all involved partners.
- **Newsletters:** general information will be spread in a newsletter 2 times per year per case area. They will be distributed by available channels from other networks such as grower’s associations and technology platforms in local case.
- **Factsheets:** will show the expected result, novel techniques, data and benefit for the users, expected costs and Best Management Practices (BMP) developed in WP3. Draft versions will be made available at the beginning of the project, which will be updated in time, according to new insights and feedback from stakeholders.

Plan for demonstration

The planning of the demonstration is organised according to the scheme presented in **Table 1**. (see also D7.4).

Table 1. Demonstration: Planning and Progress.

Month	What	Who	What
M6	Partner websites available	All case areas	website
M6	Newsletters about AGRINUPES objectives in all case areas	All case areas	news
M8	Organising first UNG-meeting (building the UNG)	All case areas	UNG
M14	Communicate with UNG the draft factsheets and BMP and get feedback for the design process	All case areas	Factsheets, BMP
M23	2 nd UNG-meeting and demonstration of first prototypes	All case areas	UNG
M25	Newsletters on websites, public deliverables available	All case areas	news, website, reports, press release
M35	3 rd UNG-meeting and demonstration of final prototypes	All case areas	UNG, reports
M36	Newsletters on websites, public deliverables available, press release	All case areas	news, website, reports, press release

Progress

In the **first year** all case study areas have set-up a national website to inform about the AGRINUPES activities (INESTEC, WUR, RISE, SUEN). So far, newsletters were made in 2 countries (NL, PT). In the Netherlands a first UNG meeting was organised and a preliminary UNG of 9 stakeholders was formed (English, D7.2.1). Draft factsheets were made available and could be used for informing the UNGs (See **Table 1**). See Appendix 3 for a list of all activities.

In the **second year** all User Network groups were established, and first meetings were held with those. In the second year the first prototype NPK-sensor had become available. In Portugal (Business2Sea event) and The Netherlands (WaterEvent 2019) this first prototypes were shown to the UNGs (Autumn 2019). Other UNGs planned their presentation later in 2020. Due to the COVID-19 situations the meetings of the UNGs were postponed, and as such there has been no possibility to show the prototype to those UNGs. Research results of the NPK and Biosensor

have been communicated to a wider scientific audience through papers and (inter)national conference contributions (Posters in Annex2 and see also D7.3 and D7.4). Sweden did plan the presentations in early 2020, but due to the COVID-19 situation this had to be postponed.

The prototype biosensor came available for application in laboratory situations beginning 2020. The consortium did not yet finalise the testing of the biosensor, in order to show results to the UNGs for the second year. All remaining work for this was postponed to the third reporting year.

In the **third year (2020, M33-M45)** the final activities in all Use Case areas were:

UPT (Portugal):

To conclude the research on the NPK-sensor, and prior to field testing at the growers, end of November 2020, nutrient solutions similar to those utilized commercially were functionally tested by INESC-TEC under lab conditions. The planning is to visit with INESC-TEC 1 or 2 local growers to test the NPK sensor, before the final webinar in December 2020. No field tests or demonstrations were performed in 2020. Final results of this work are to be reported in D5.3, "Performance of both sensors in a 'CRUs' and guidelines for BMP".

SUEN (Turkey):

Open-field study in Konya was planned to be conducted in the presence of relevant stakeholders (UNG group) once the sensors were ready to be tested. However, it could not be carried out in open-field due to the pandemic, thus samples had to be sent to Ege University labs for analysis via biosensors for pesticides only. Since a field visit could not be carried out face-to-face with the UNG group, a short survey has been prepared to understand the hindrances in current agricultural practices, gaps in related policies and stakeholders' initial thoughts on employing sensors in their practices.

The inquiries with farmers and authorities showed that all parties are interested in employing new technologies, but it is important that these tools are introduced to users through demonstration projects first by explaining their advantages clearly, rather than adopting a mandatory approach and obliging their use.

Final results are reported in D6.4. "Report on Konya Basin field application results".

RISE (Sweden):

Due to Covid no more meetings have been performed. An article presenting the results of AGRINUPES will be finalized in December and will be published in Sweden's professional horticultural business magazine Viola Trädgårdsvärlden in January 2021 <https://www.viola.se/>.

A technical demonstration of the sensors was also planned this spring in the beginning of April but it was postponed to August due to Covid-19. Due to the fact that the sensors were not fully evaluated in August and the restrictions due to Covid-19 were still in place, no demonstration have been possible to perform.

WUR (The Netherlands):

In 2020 the annual Water Event at Bleiswijk was cancelled due to the corona pandemic. It was decided not to have another separate event (f.i. a webinar) in 2020. The planning for demonstration is to do it at next year Water Event and combine the results from the AGRINUPES project with a Dutch follow-up project on a nitrate hand meter.

Final results for the use of the NPK-sensor in Dutch greenhouses is reported in D3.4 and D3.5.

In 2020 WUR started-up a Dutch funded follow-up project to explore the use of the NPK-sensor prototype technologies in order to develop a hand meter for nitrate. It should be usable for growers to monitor water solution inside or outside their greenhouse, f.i. to detect leakages from their greenhouse.

RITEC (Spain):

As the NPK-sensor prototype was tested at the end of 2020, INESC TEC will proceed with the work with RITEC after the end of the project to test in real operating conditions the NPK sensor and controller.

3. Conclusion

In the Use Case areas Portugal, The Netherlands, Turkey and Sweden, User Network Groups have been set-up. Stakeholders have been informed about the targets of the AGRINUPES project, via national websites, group meetings, poster presentations, magazine articles, and international scientific conferences.

The prototype NPK-sensor have become available in the second year and for Portugal and The Netherlands it was demonstrated in 2019. Sweden did plan the presentations in early 2020, but due to the COVID-19 situation this had to be postponed. The final prototype NPK-sensor was tested by the end of 2020 but could not be demonstrated in one of the use case areas yet.

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Annexes

Annex 1: Summary of Case Study dissemination activities

Case Study Portugal (INESTEC, FCUP)

User Network Group (UNG) establishment:

- Portuguese UNG established (24-9-2018; M18) during the meeting “1st User Network Group Meeting of the Soilless Cultivation Sector”, organized by INESC TEC and FCUP, and held at Campus de Vairão (FCUP, Vila do Conde, Portugal)

News on Media websites:

- AGRINUPES page at the Water JPI website (M1, INESC TEC, www.waterjpi.eu/index.php?option=com_content&view=article&id=545:agrisensus&catid=156:joint-calls).
- INESC TEC website: <http://criis.inesctec.pt/index.php/criis-projects/agrisensus/>
- GreenUPorto – Research Center on Sustainable Agrifood Production website (<https://www.fc.up.pt/GreenUPorto/en/projects/>)
- Portuguese news at UP online (<https://noticias.up.pt/inesc-tec-e-fcup-querem-maior-eficiencia-no-uso-de-agua-na-agricultura/>, 19-12-2016)
- Portuguese news at REDE INOVAR (<http://pt.skanplatform.org/posts/1760> , 22-12-2016)
- Portuguese news item at public news site (<https://www.publico.pt/2017/01/05/tecnologia/noticia/sensores-portugueses-poupam-agua-na-producao-agricola-1757229>, 5-1-2017)
- Portuguese news item at agronegocios.eu (<http://www.agronegocios.eu/noticias/novos-sensores-permitem-aumentar-eficiencia-do-uso-da-agua-na-producao-agricola/>, 7-1-2017)
- Portuguese news item at FCUP website (https://sigarra.up.pt/fcup/pt/noticias_geral.ver_noticia?p_nr=43673, 13-3-2019)
- Portuguese news item at VOZ DO CAMPO website (<https://vozdocampo.pt/2020/11/26/projeto-agrinupes-promove-o-seu-webinar-final/>, 26-11-2020)
- Portuguese news item at INESC TEC website (<https://www.inesctec.pt/en/clipping/agrinupes-project-promotes-the-final-webinar#intro>, 26-11-2020)
- Portuguese news item at AGROTEC website (<http://www.agrotec.pt/noticias/projeto-agrinupes-promove-o-seu-webinar-final/>, 27-11-2020)
- Portuguese news item at REDE RURAL website (https://inovacao.rederural.gov.pt/9-destaque-inov/1091-webinar-final-do-projeto-agrinupes-4-dezembro-2020?cookie_4edc832c64da52717aa377e8ae55a36b=accepted, 30-11-2020)
- Portuguese news item at AGROPORTAL website (<https://www.agroportal.pt/projeto-agrinupes-promove-o-seu-webinar-final-4-de-dezembro/>, 2-12-2020)
- Portuguese news item at GreenUPorto – Research Center on Sustainable Agrifood Production website (<https://www.fc.up.pt/GreenUPorto/en/news-events/>, 2-12-2020)

Oral communications:

- Santos, MG, Pereira, R, Carvalho, SMP. 2018. Assessment of the potential for reusing the drainage in semi-hydroponic production systems: Portuguese case studies. In: Workshop on water quality management: attending the United Nations call for sustainable development. Faculty of Sciences of the University of Porto. Porto, Portugal: 18 May.
(<https://www.dropbox.com/s/6icc0vymnvzprbv/Workshop18May2018.pdf?dl=0>)
- Carvalho, SMP, Santos, MG, Pereira, R. 2018. Portuguese case study: potential applications and future perspectives (in Portuguese). In: 1st User Network Group Meeting of the Soilless Cultivation Sector. Vila do Conde, Portugal: 24 Sep.
(<https://www.dropbox.com/s/zmqstfnthhjv8x1/UNGMettingPortugal.pdf?dl=0>)
- Carvalho SMP, Santos, MG, Pereira, R. 2018. Challenges faced by the Protected Cultivation Sector taking into account the climate changes. In: 'Seminário de Agricultura de Precisão - Pontes para uma agricultura melhor num cenário de alterações climáticas'. Universidade de Trás-os-Montes e Alto Douro (UTAD), Vila Real, Portugal: 27 Sep.
(<https://www.dropbox.com/s/e2b2w7o9qe9pm40/AgriculturaPrecisao.pdf?dl=0>)
- Santos, MG, Pereira, R, Carvalho SMP. 2019. Assessment on the impact of soilless semi-open systems and potential for reusing the drainages - contribution for a more efficient fertigation management. In: 'GreenUPorto Scientific Seminars'. Faculty of Sciences of the University of Porto. Porto, Portugal: 20 Mar.
(<https://www.dropbox.com/s/bf5s1lgraj79599/SeminarMarch2019.pdf?dl=0>)
- Santos, MG, Pereira, R, Carvalho, SMP. 2019. Potential reuse of drainage solutions from three soilless crops grown under Mediterranean conditions. In: IX International Symposium on Irrigation of Horticultural Crops. ISHS. Matera, Italy: 17-21 June.
(<https://www.dropbox.com/s/m30m8i84homcedf/PresentationJune2019.pdf?dl=0>)
- Santos, MG, Pereira, R, Carvalho, SMP. 2020. Assessing the suitability of using drainage from hydroponics in soil cultivation: Portuguese case studies within the framework of the EU-project AgriNuPes. In: "From soil to fork" Sustainable Agrifood Production Seminars. Faculty of Sciences of the University of Porto. Porto, Portugal. 19 Aug.
(<https://www.dropbox.com/s/ya1ucbnh4pryb21/Summerschool.pdf?dl=0>)
- Carvalho SMP, Santos, MG, Aguiar, A, Pereira, R. 2020. WP 5 Case Region Portugal: Assessing the suitability of using drainage from hydroponic systems in soil cultivation Cascade ReUse Systems – CRUS. In: Final AgriNuPes Webinar. 4 Dec.
(<https://www.dropbox.com/s/u83120a8j94a7pm/FinalWebinar.pdf?dl=0>)
- AGRINUPES Prototype at Business2Sea, 2019. Congress Centre Alfândega do Porto, Portugal 14th-16th November 2019.

Poster presentations:

- Poster presentation in Agri Innovation Summit 2017.
(<https://www.dropbox.com/s/ekb6xnf0bxlnifd/Agri.Innovation.pdf?dl=0>)
- Poster presentation (in Portuguese) in the 1st Portuguese-Brazilian Congress on Horticulture, 1-4 November 2017, Lisbon, Portugal. "Caracterização da gestão da fertirrega e da aplicação de produtos fitofarmacêuticos em culturas sem solo em Portugal: primeiros passos" (Annex 2, Poster 1).
- Poster presentation in FCT Evaluation Panel Meeting, 19 October 2018, Vila do Conde, Portugal. "Assessment on the impact of soilless semi-open systems and applicability of sensors for a more efficient fertigation management" (Annex 2, Poster 2).

- Poster presentation in SETAC Europe 29th Annual Meeting, 26-30 May 2019, Helsinki, Finland. “Ecotoxicological impact of semi-open horticultural systems on irrigation water quality” (annex 2, Poster 3).
- Poster presentation in the 13th Meeting of Young Researchers, 12-14 February 2020, Porto, Portugal. “Which are the impacts of using drainage from a hydroponic system on lettuce (*Lactuca sativa*) cultivation?” (Annex 2, Poster4).

Project reports (public):

- Santos, MG, Pereira, R, Aguiar, A, Carvalho, SMP. 2017. Report on General Characterization of the CascadeReUse Systems. Deliverable 5.1. 28 Nov. Available at: https://www.agrinupes.eu/wp-content/uploads/2018/03/D5.1-Report-v05_FINAL.pdf
- Santos, MG, Aguiar, A, Pereira, R, Carvalho, SMP. 2020. Suitability and impacts of ‘CascadeReUse Systems’ on irrigation water and soil. Deliverable 5.2. 10 Jan. Available at: <https://www.agrinupes.eu/wp-content/uploads/2020/04/Deliverable-5.2-final-version-.pdf>
- Nn, 2020. Performance of both sensors in a ‘CRUs’ and guidelines for BMP (D5.3, M36, FCUP). Not yet available.

Articles published or submitted:

- (Published) Santos, MG, Roncon, I, Pereira, R, Carvalho, SMP. 2018. Characterization of the Portuguese management practices of fertigation and phytochemicals’ application in soilless cultivation (in Portuguese). In: Actas Portuguesas de Horticultura No 29: 611-619. Associação Portuguesa de Horticultura (APH), Portugal. Available at <http://clbhort2017.com/wp-content/uploads/2018/03/29-Actas-Portuguesas-de-Horticultura.pdf>
- (Submitted) Santos, MG, Moreira, GS, Pereira, R, Carvalho, SMP. Assessing the potential use of drainage from open soilless production systems: a case study from an agronomic to an ecotoxicological perspective.

Case Study The Netherlands (WUR):

- Dutch website at WUR online (M3, WUR, <https://www.wur.nl/en/newsarticle/Integrated-monitoring-and-control-of-water-nutrients-and-plant-protection-products-towards-a-sustainable-agricultural-sector.htm>).
- User Network Group (NL) established (M7). Contributing stakeholders: Technology suppliers (8), Water Authorities (4), Nutrient suppliers (1), Scientific Institutes (2), Greenhouse Horticulture sector and growers (5), Press (1).
- AGRINUPES in the EIP Water Conference 2017: WIRE brochure (M6, WUR, see Appendix 2).
- UNG meeting at the “Annual WATER-day” in Bleiswijk (NL), Oct 5th, 2017 (M7). Stakeholder consultation meeting to inform about the progress and to get feedback from the end-users.
- UNG meeting at the “Annual WATER-day” in Bleiswijk (NL), Oct 4th, 2018 (M19). Stakeholder consultation meeting to inform about the progress and to get feedback from the end-users and poster presentation (Poster 5).
- UNG meeting at the “Annual WATER-day” in Bleiswijk (NL), Oct 3rd, 2019 (M31). Stakeholder consultation meeting to inform about the progress and to get feedback from the end-users, poster presentation (Poster 6) and demonstration NPK-sensor prototype.
- News item “AGRINUPES – Sensoren voor nutriënten en gewasbeschermingsmiddelen” on website (M3, WUR, www.wur.nl/nl/nieuws/AGRINUPES-Sensoren-voor-nutriënten-en-gewas-beschermingsmiddelen.htm).

- Newsletter “Europees project ontwikkelt nieuwe sensoren voor nutriënten en gewasbeschermingsmiddelen” to local Dutch Network (29-7-2018, M5, LTO-Groeiservice, www.glastuinbouwwaterproof.nl/nieuws/europees-project-ontwikkelt-nieuwe-sensoren-voor-nutriënten-en-gewasbeschermingsmiddelen/)
- News item “Sensoren voor meststoffen en gewasbeschermingsmiddelen”, on website: www.glastuinbouwwaterproof.nl/nieuws/sensoren-voor-meststoffen-en-gewasbeschermingsmiddelen/ (27-12-2017, M9, LTO-groeiservice, Harry Stijger) Notification at Dutch funding organisation RVO (<https://www.rvo.nl/era-net-waterworks>)
- <https://hortinext.nl/sensoren-voor-meststoffen-en-gewasbeschermingsmiddelen/> (Hortinext, 19-3-2018)
- Dutch annual project report (BO-20-003-059, M10, WUR, In Dutch).
- Jim van Ruijven, 2019. Water Use Efficiency in greenhouse horticulture, presentation for AGRINUPES consortium at Wageningen University & Research, BU Greenhouse Horticulture, Bleiswijk, 16-10-2019.
- Jos Balendonck, 2019. AGRINUPES, Integrated Monitoring and Control of Water, Nutrients and Plant Protection Products Towards a Sustainable Agricultural Sector. Presentatie bij Min. LNV t.b.v. R. Metaal, Den Haag, 4-7-2019 (Confidential).
- Geert Franken, Erik van Os, Arjan Vroegop, Jos Balendonck, 2020. Evaluation of a nitrate sensor for Dutch greenhouses at semi-practical scale (D3.4, M36, WUR).
- Erik van Os, Jos Balendonck, 2020. Best Management Practices Use Case: the Westland Region (NL) (D3.5, M45, WUR).
- G. Franken, J. Balendonck, E.A. van Os and A. Vroegop, 2021. Development of a robust nitrate sensor for online measurements. To be presented at the 3rd International Symposium on Soilless Culture and Hydroponics, in Limassol (Cyprus) on 21-24 March 2021 (In prep.).

Case Study Turkey (SUEN, EGE)

- Turkey website at SUEN online (<https://suen.gov.tr/faaliyetlerimiz/projeler/>).
- User Network Group (TR) established (M12). Contributing stakeholders: Local Water and Agriculture Authorities (6), Scientific Institutes (2), Farmers Cooperative and Private Sector (2).
- Turkey website from EGE online at Research Gate Net (<https://www.researchgate.net/project/AGRINuPeS-INTEGRATED-MONITORING-AND-CONTROL-OF-WATER-NUTRIENTS-AND-PLANT-PROTECTION-PRODUCTS-TOWARDS-A-SUSTAINABLE-AGRICULTURAL-SECTOR>).
- Presentation at Thematic Workshop 'Water management and uses – nexus with climate and food', Dushanbe, Tajikistan 25 June 2019. Osman TIKANSAK, Turkish Water Institute (SUEN), 2019. AGRINUPES (Integrated Monitoring and Control of Water, Nutrients and Plant Protection Products Towards a Sustainable Agricultural Sector).
- UNG meeting in Konya (TR), Oct 10th, 2018 (M19). Stakeholder consultation meeting to inform about the goals of the project and to get feedback from the end-users. Presentation about the progress of AGRINUPES.
- Survey study with UNG group and farmers (March 2020). Planned to be conducted face-to-face in Konya, cancelled due to Covid-19. Conducted remotely by sending the survey via e-mail to stakeholders.
- Ceren Durmus, Burcu Yazıcı, 2020. Report on Konya Basin field application results (D6.4, M45, EGE).

Case Study Spain (Ritec):

- Spanish website at Ritec (<http://www.ritec.es/sistemas-riego-fertirrigacion/proyectos-de-investigacion.html>)
- First User Network Group Meeting in Spain (RITEC). Madrid, Spain (Fruit Attraction), 23rd October 2018.

Case Study Sweden (RISE):

- Swedish partner website at RISE (<https://www.sp.se/sv/units/risebiovet/fb/forskning/euprojekt/Sidor/default.aspx>).
- User Network Group (SE) Established 29-3-2018.
- Two meetings performed and with input from growers and stakeholders.
 - 29/3/2019 (9:30-11:30). Sånnagården, Klippan, Sweden (at cucumber grower and café owner with vegetable production in focus), 34 growers.
 - 4/4/2019 (13:00-15:30). Orevads Handelsträdgård, Hörby, Sweden (at pot plant producer, with pot plant production in focus), 37 growers.
- Swedish partner website at RISE (<https://www.ri.se/sv/vad-vi-gor/projekt/agrinupes-sensorer-vattenkvalitet>).
- The project has been showed and discussed at Borgeby Fältdagar that is a large field fair in Sweden normally held in the end of June, with approximately 20 000 visitors, every year. The intension was to show the sensors this year as well but due to the Covid-19 the fair is cancelled 2020.
https://www.borgebyfaltdagar.se/?page=facts_about_borgeby_faltdagar&p=2024&m=1645
- One smaller article has been written and published in Sweden's professional horticultural business magazine Viola Trädgårdsvärlden and an article with the final results of AGRINUPES are planned in October 2020. <https://www.viola.se/>.

Annex 2. Leaflets and posters

WIRE brochure

AGRINUPES: MONITORING AND CONTROL OF WATER, NUTRIENTS AND PESTICIDES



- Promoter** *Institute for Systems and Computer Engineering, Technology and Science (INESC TEC)*
- Period** *Since 2017 (until 2020)*
- Location** *Europe (Portugal, Spain, Turkey, Sweden, The Netherlands)*
- Objective** *Development of an effective integrated and sustainable monitoring and control system with innovative ion selective sensors for nutrients and bio-based sensing of pesticides for optimal water and nutrient supply and reuse, minimizing the effects on the environment.*
- Target Audience** *Farmers, Technicians, Policy/Decision Makers, Scientist/Researchers.*
- Level** *International (Europe), National, Regional*
- Accessibility** *Open days organised during 2018-2019 at several demo-sites in Porto (P), Murcia (ES), Konya (TR), Bleiswijk (NL). Contribution to Network User Groups.*
- Contact** *jose.boaventura@inesctec.pt
jos.balendonck@wur.nl*



Project description

For optimizing plants needs while minimizing the environmental impacts, sustainability and competitiveness of European agriculture are intrinsically related to the efficient use of water, fertilisers and plant protection products (PPP). Good Agricultural Practices - in the context of the circular economy- force growers to minimize their wastewater and thus optimize the use of nitrogen and phosphorus-based fertilizers and PPPs. Better management requires reliable decision-making systems (DSS) based on water quality feedback making use of cost-effective, robust, low-maintenance and accurate sensors for nutrients and pesticides. So far, available sensor technology does not meet the challenges for on-site monitoring. The project intends to develop such sensors and integrate them into fertigation equipment, with demonstration of their use for practical management purpose at several European demo-sites.

Results obtained so far

- R&D of an integrated and sustainable monitoring system with innovative ion selective sensors for nutrients (NPK) and bio-based sensing of pesticides (IMIDACLOPRID and PIRIMICARB); to be used for optimal water and nutrient supply and reuse, minimizing the effects on the environment (prototypes expected 2017-2018).
- An easy-to-use, robust and fault-tolerant fertigation controller, to meet both crop needs and grower yield/costs expectations (prototype expected 2017-2018).
- Validation and demonstration the applicability of developed technologies at four sites covering several types of crop production systems (recycled or cascaded water system) from greenhouses to open-field agriculture in various climatic regions (expected 2019-2020).
- Monitoring and Control Products available for the market (expected 2020 ...).

Success factors

The project builds on the extensive experience, competence and early work conducted on optical fibre-based sensors, biosensors, water policy models, plant nutrition, smart irrigation scheduling and robust control. It is implemented by a trans-disciplinary team of experts involving multi-actors. The demonstration sites will be open during 2018-2020 for visiting. Farmers, suppliers, scientists, water boards and policy makers are welcome to visit these demo-sites at open days. Relevant stakeholders may join the regional Network User Groups set-up around the demo-sites in order to be informed during the research and development phase of the technologies. Their input is valuable for the project in order to tune the systems to the end-user needs.

Performance indicators

The new sensors will lead to worldwide new markets for European water technology sector, thus strengthening the competitiveness and growth of SMEs and related companies. As a result, significant increase of water and fertilizer use efficiency is obtained in the agricultural/horticultural sector (expected < 50%), longer and economic reuse cycle for the drainage water is achieved, and pollution of surface and ground waters by fertilizers and PPP is prevented or significantly reduced.

Repeatability & Applicability

With the sensors, growers will have information about the input and output water quality and can evidence-based decide on how and when to irrigate and fertigate, and on whether the costly task of cleaning is advisable before disposal. Governmental organizations (water authorities) may use sensors for checking water quality (pesticides) in ground and surface waters. Technology suppliers (re-sellers of equipment for agricultural practices) can acquire a license to sell the sensors and decision support systems world-wide.

Further references

The project “Integrated monitoring and control of water, nutrients and plant protection products towards a sustainable agricultural sector” is funded by: ERA-NET / Co-fund WaterWorks2015.

PROJECT COORDINATOR:

Dr. José Boaventura-Cunha, INESC TEC, R. Dr. Roberto Frias, 4200-465 Porto, Portugal

E-mail: jose.boaventura@inesctec.pt Website: www.agrinupes.es


Caracterização da gestão da fertirrega e da aplicação de produtos fitofarmacêuticos em culturas sem solo em Portugal: primeiros passos

Miguel G. Santos¹, Isabella Roncon¹, Ruth Pereira^{2,3}, Susana M.P. Carvalho^{1,2,3}

¹GreenUP/CITAB-UP, Faculdade de Ciências da Universidade do Porto, Campus Agrário de Vairão, Rua Padre Amaro Quintas 7, 4485-661 Vairão, Portugal
² Departamento de Biologia & GreenUP/CITAB-UP, Faculdade de Ciências da Universidade do Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal
³ CIIMAR, Centro Interdisciplinar de Investigação Marinha e Ambiental, Universidade do Porto, Terminal de Cruzeiros do Porto de Leixões Av. General Norton de Matos s/n 4450-208 Matosinhos, Portugal
 E-mail: susana.carvalho@fc.up.pt



Introdução



Projeto AgriNUPes
www.agrinupes.eu

Objetivo Geral: desenvolvimento e teste de sensores económicos e expeditos para a monitorização de macronutrientes (NPK) e de Produtos Fitofarmacêuticos (PF) de modo a otimizar o uso destes recursos

Em culturas protegidas sem solo (Estudo de caso Português):

Sistemas de produção

- Aberto – drenagem livre
- “Em cascata” – drenagem reutilizada em culturas secundárias
- Fechado – recirculação da drenagem na cultura principal

Sensores:

- Optimização da fertirrega
- Redução do impacto ambiental
- Suporte à tomada de decisão sobre a reutilização da drenagem
- Promoção de sistemas com reaproveitamento da solução nutritiva

Objetivos

Caracterização dos produtores nacionais de culturas sem solo, relativamente à gestão da fertirrega e da aplicação de PF

Informação útil para a definição das especificações dos sensores

Material e Métodos

1 Questionário com quatro secções:

- Caracterização da empresa e do produtor
- Caracterização do sistema de produção
- Caracterização do sistema de rega
- Caracterização dos PF utilizados

2 Seleção dos Inquiridos segundo pré-requisitos definidos (n=12):

- Com culturas sem solo
- Culturas escolhidas: tomate, morango e flores de corte
- De culturas e regiões com representatividade em Portugal
- Regiões escolhidas: Entre-Douro-e-Minho* e Oeste**

* presencial ** via email ou telefone

3 Análise dos dados

Questões que permitem várias opções de resposta: as frequências relativas de resposta foram calculadas considerando cada opção individualmente. Assim, a soma das frequências de resposta poderá ser superior a 100 %.

Resultados

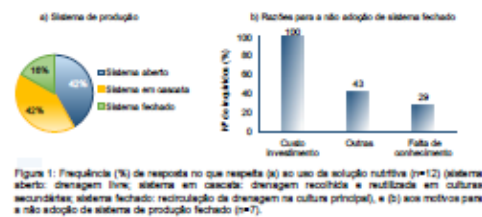


Figura 1: Frequência (%) de resposta no que respeita (a) ao uso de solução nutritiva (n=12) (sistema aberto: drenagem livre; sistema em cascata: drenagem recolhida e reutilizada em culturas secundárias; sistema fechado: recirculação da drenagem na cultura principal), e (b) aos motivos para a não adoção de sistema de produção fechado (n=7).

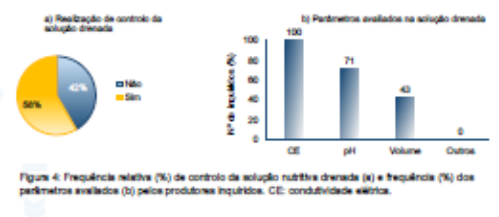


Figura 4: Frequência relativa (%) de controlo da solução nutritiva drenada (a) e frequência (%) dos parâmetros analisados (b) pelos produtores inquiridos. CE: condutividade elétrica.

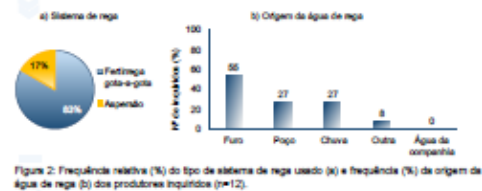


Figura 2: Frequência relativa (%) do tipo de sistema de rega usado (a) e frequência (%) da origem da água de rega (b) dos produtores inquiridos (n=12).

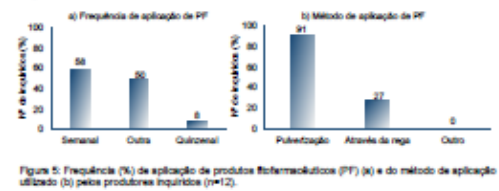


Figura 5: Frequência (%) de aplicação de produtos fitofarmacêuticos (PF) (a) e do método de aplicação utilizado (b) pelos produtores inquiridos (n=12).




Figura 3: Frequência (%) do método usado, pelos produtores inquiridos (n=12), para o controlo das necessidades de rega.

Conclusões

- Elevada percentagem de produtores que não aproveita a solução nutritiva drenada (42 %), principalmente pelo custo do investimento;
- A gestão da fertirrega é maioritariamente feita de forma empírica (75 %);
- Existe margem significativa para o aumento da eficiência do uso dos recursos hídricos e dos nutrientes em sistemas de produção sem solo em Portugal.

Agradecimentos

Os autores agradecem à UE e à FCT pelo financiamento ao Projeto WaterJPI002/2015, no âmbito do consórcio colaborativo internacional AGRINUPES, financiado pelo ERA-NET WaterWorks2015. Este ERA-NET é parte integrante das Atividades Conjuntas 2018 desenvolvidas pelo Water Challenges for a Changing World Joint Programme Initiative (Water JPI).



Assessment on the impact of soilless semi-open systems and applicability of sensors for a more efficient fertigation management

Miguel Gomes Santos^a, Ana Aguiar^a, Ruth Pereira^b and Susana M. P. Carvalho^c

^a GreenUPorto & DISAOT, Faculty of Sciences of the University of Porto, Campus de Vairão, Rua da Agrária 747, 4483-646 Vile do Conde, Portugal

^b GreenUPorto & Department of Biology, Faculty of Sciences of the University of Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal

^c PI at FCUP and WPS coordinator: susana.carvalho@fc.up.pt

AGRINUPES Project

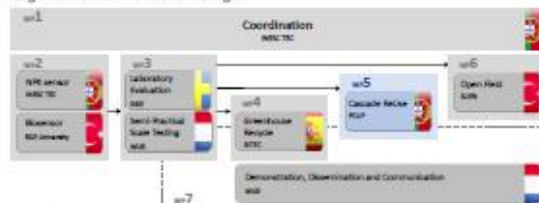
Full title: AGRINUPES - Integrated monitoring and control of water, nutrients and plant protection products towards a sustainable agricultural sector (www.agrinupes.eu)

Total budget: €1.08M (ERA-NET CDFUND WATERWORKS 2015)

Duration: 36 months (04/2017 – 03/2020)

Consortium of 8 entities from 5 countries

Organization of the Work Packages



INTEC - Institute for Systems and Computer Engineering, Technology and Science | IISG University | IISG Life Sciences | IISG - Research Institute of Oceanography | Wageningen University & Research | INTEC - Ingenieros Tecnológicos, S.L. | FCUP - Faculty of Sciences of University of Porto | ICRP - Turkish Akdeniz Institute

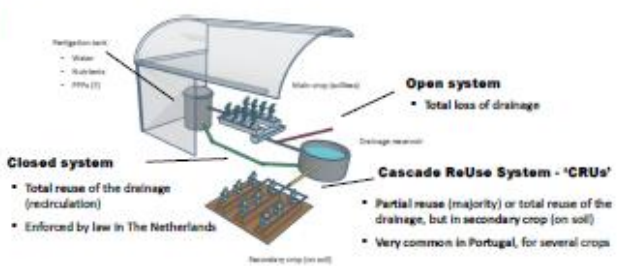
Motivation

- Losses of water and nutrients due to poor implementation of closed fertigation systems in soilless crops
- Need for reducing the releases of fertilizers and Plant Protection Products (PPPs) to the environment

Goals

- Development of ion selective optical sensor (NPK) and biosensor (detection of PPPs residues)
- To improve the efficiency of water and nutrients use and reduce the environmental impact of soilless cultivation systems, by means of higher recirculation of the drainages

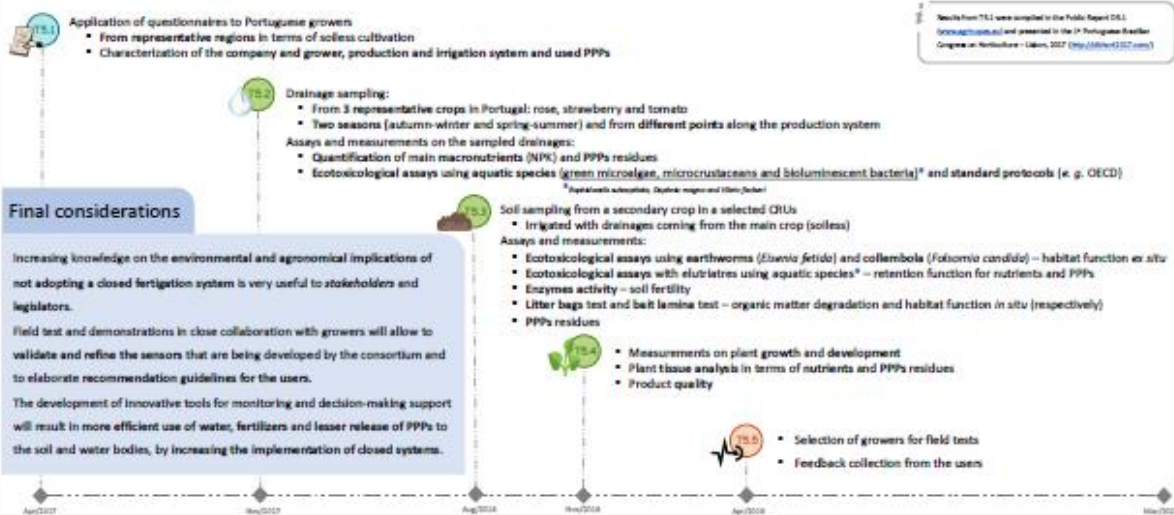
Semi-open or Cascade ReUse Systems ('CRUs')



Tasks and specific objectives from WPs



Methodologies



Final considerations
 Increasing knowledge on the environmental and agronomical implications of not adopting a closed fertigation system is very useful to stakeholders and regulators.
 Field test and demonstrations in close collaboration with growers will allow to validate and refine the sensors that are being developed by the consortium and to elaborate recommendation guidelines for the users.
 The development of innovative tools for monitoring and decision-making support will result in more efficient use of water, fertilizers and lesser release of PPPs to the soil and water bodies, by increasing the implementation of closed systems.

Acknowledgements

The authors would like to thank the PI and the ACT for funding. In the frame of the collaborative international Consortium AGRINUPES, financed under the ERA-NET WaterWorkS2015 Collaborative Call. This ERA-NET is an integral part of the 2015 Joint Activities developed by the Water Challenges for a Changing World Joint Programme Initiative (Water-JP).



Ecotoxicological impact of semi-open horticultural systems on irrigation water quality

Miguel Gomes Santos¹, Ruth Pereira² and Susana M. P. Carvalho²

¹GreenUPorto Sustainable Agrifood Production Research Centre & DGAOT, Faculty of Sciences of the University of Porto, Campus de Vairão, Rua da Agrária 747, 4485-646 Vila do Conde, Portugal

²GreenUPorto Sustainable Agrifood Production Research Centre & Department of Biology, Faculty of Sciences of the University of Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal

Corresponding authors: ruth.pereira@fc.up.pt; susana.carvalho@fc.up.pt

Introduction

> Soliflex cultivation can be highly efficient in the use of water and fertilizers, when the drained nutrient solution is recirculated (closed systems).

But...

Open (free drainage) and semi-open systems (Cascade ReUse Systems or CRUS) (drainage reuse for fertigation of secondary crops grown on soil) are still very common even in regions (e.g. Mediterranean) where forecasted climate changes point for less water availability.

- > Poor use efficiency of water and nutrients;
- > Releases of fertilizers and Plant Protection Products (PPPs) residues to the environment.

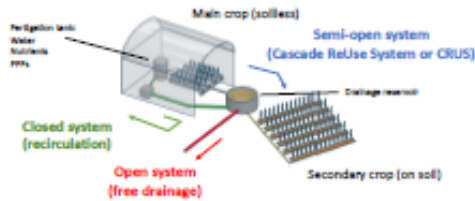


Figure 1. Schematic representation of the types of semi-hydroponic systems, regarding drainage reuse.



> The Project AgriNuPer (www.agrinupes.eu) is developing a NPK optical sensor and a biosensor (detection of PPPs) to:

- > Improve the fertigation management in soliflex cultivation;
- > Increase the implementation of closed systems;
- > Consortium of 8 entities from 5 countries;
- > FCT/PT (Portugal) is responsible for the Work Package targeting the environmental safety of drainages from CRUS.

Objective

> As part of the aforementioned project, this work aims to assess the quality of drainages from CRUS and their potential reuse through the characterization of their chemical composition and toxicity to aquatic organisms.

Materials and methods

> Two case studies (CRUS from Portuguese commercial growers):

- > Rose CRUS;
- > Strawberry CRUS.

> Collection points of drainage samples:

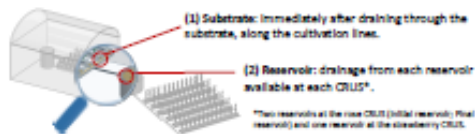


Figure 2. Schematic representation of the sampling points where the drainage from CRUS were collected.

> Ecotoxicological assays using aquatic species and standard protocols:

- > *Aphidocolax subopifera* (green microalgae) – growth inhibition assay (OECD 201, 2011);
- > *Daphnia magna* (microcrustacean) – immobilization assay (OECD 202, 1984);
- > *Aliivibrio fischeri* (bioluminescent bacteria) – Microtox® acute toxicity assay (E1.9% Basic Test Protocol, Modernwater);
- > Quantification of total nitrogen and total phosphorus (colorimetric method, Hanna Inst.);
- > Quantification of PPPs residues by LC-MS.

Results and discussion

> *A. subopifera* growth was inhibited only by the drainages from the rose CRUS (Table 1);

> Probably due to the higher PPPs residue in the drainage from this CRUS (Table 2);

> The drainages from both CRUS were highly toxic to *D. magna*;

> The electrical conductivity (EC) may be responsible at least in part for the toxicity of the drainages to the cladocerans, as they still have considerable levels of nutrients (Table 3);

> The PPPs residue found in the drainages, might also have contributed to this toxicity.

> No toxic effect to *A. fischeri* were recorded. In opposition the drainages provoked a stimulation of the bacteria bioluminescence;

> The large availability of nutrients in the drainage can be suggested as one of the reasons for the stimulation on the bacterial metabolism;

> The results suggest that the drainages of rose cultivation might be more harmful to the environment due to higher nutrient levels and PPPs residues, as compared to strawberry cultivation.

Table 1. Results of the ecotoxicological assays performed to assess the drainages from the two CRUS under evaluation.

Drainages	<i>A. subopifera</i> 72h-EC ₅₀ [N]* [95% CI]	<i>D. magna</i> 48h-EC ₅₀ [N]* [95% CI]	<i>A. fischeri</i> HE [N]*
Rose CRUS			
Substrate	63 (57-70)	0 [nc]	19
Initial Reservoir	Non-toxic	21 (11-28)	-11
Final Reservoir	Non-toxic	38 (9-24)	-24
Strawberry CRUS			
Substrate	Non-toxic	48 (43-52)	-47
Reservoir	Non-toxic	11 (9-12)	-41

* 72h-EC₅₀ is the effective concentration of drainage at which growth of *A. subopifera* was inhibited by 50%, after 72 h of exposure.

* 48h-EC₅₀ is the effective concentration of drainage that caused immobilization in 50% of the cladocerans *D. magna*, after 48 h of exposure.

* HE is the highest effect on the bioluminescence of *A. fischeri*. Negative values indicate inhibition, rather than stimulation. Non-toxic maximum effect <10% [nc] not calculated.

Table 2. Plant Protection Products residue in the drainages from the two CRUS under evaluation.

Drainages	Metolachlor (µg/L)	Pyrimorfin (µg/L)	Azoxystrobin (µg/L)	Diflufenican (µg/L)	Fluoxifenil (µg/L)	Boscalid (µg/L)
Rose CRUS						
Substrate	2.14	0.09	0.72	12.1	0.272	3.30
Initial Reservoir	0.45	0.14	0.23	300.0	0.321	0.73
Final Reservoir	0.20	0.17	0.26	36.1	0.396	1.64
Strawberry CRUS						
Substrate	0.03	0.17	0.18	1.2	<0.005	0.12
Reservoir	0.01	0.05	0.17	36.2	<0.005	0.14

Table 3. Total nitrogen, total phosphorus and electrical conductivity (EC) of the drainages from the two CRUS under evaluation.

Drainages	Total N (mg/L)	Total P (mg/L)	EC (ds/m)
Rose CRUS			
Substrate	124.7 ± 9.8	42.2 ± 0.2*	1.6
Initial Reservoir	121.3 ± 6.4	3.47 ± 0.9*	1.5
Final Reservoir	140.7 ± 4.1	28.7 ± 0.2*	1.4
Strawberry CRUS			
Substrate	86.0 ± 12.1	20.6 ± 0.6*	1.5
Reservoir	51.3 ± 3.7	1.48 ± 0.2*	1.3

* Different letters indicate significant differences through Tukey's test (p<0.05), after one-way ANOVA.

Conclusions

> For a better environmental performance of soliflex cultivation, it is stressed here the importance of preventing drainages to be released into the environment, especially directly to the aquatic environment;

> This study is being complemented with the assessment of the impacts on soil of the drainages applied to secondary crops;

> The high levels of nutrients that persist in the drainages reinforces the importance of testing their potential reuse with target crops. This will be a step forward for increasing the life-cycle of drainages, to reduce this externality and the consumption of water and nutrients.

Acknowledgements
The authors would like to thank the FCT and the PT/PT (Portugal) in the frame of the collaborative International Consortium AGRINUPES financed under the FCT/PT Water4Agri2023 Collaborative Call. This ERA-MET 7.00 project is part of the 2016 Joint Activities developed by the Water Challenges for a Changing World (W4C) Programme Initiative (Water-IP).



Which are the impacts of using drainage from a hydroponic system on lettuce (*Lactuca sativa*) cultivation?

Germano S. Moreira¹, Miguel G. Santos¹, Ruth Pereira², Susana M. P. Carvalho²

¹GreenUPorto – Sustainable Agrifood Production Research Centre & DGAOT, Faculty of Sciences of the University of Porto, Campus de Valção, Rua da Agrária 747, 4485-646 Vila do Conde, Portugal

²GreenUPorto – Sustainable Agrifood Production Research Centre & Department of Biology, Faculty of Sciences of the University of Porto, Rua do Campo Alegre s/n, 4169-007 Porto, Portugal

Introduction

Agriculture's sustainable production systems are closely related to the efficient use of water, fertiliser and plant protection products (PPPs).

In soilless production, open irrigation systems are related to inefficient use of water and nutrients, as the surplus nutrient solution (drainage) is discharged without reuse, releasing fertiliser and PPPs to the environment (free drainage).

The implementation of closed and semi-open (Cascade ReUse Systems or CRUS) irrigation systems would highly contribute to a lower environmental impact, since the drains can be recirculated or reused for fertigation of secondary crops grown on soil.

However, in order to infer on the potential reuse of the drainage it is important to assess the effect of their recirculation on crops.



This work was performed within the framework of the European project AgrinUpes (<https://www.agrinupes.eu>) whose main objective is the development of sensors to monitor water, nutrients and PPPs in an integrated way:

Non selective optical sensor (NFS)

Sensor to monitor PPP residues

FCUP is responsible for the Work Package 5 – Cascade ReUse – targeting the environmental safety of drainages from semi-open irrigation systems and the evaluation of the appropriateness of applying drains to a crop from an agronomic and food safety point of view.

Objective

This work had as specific objective evaluating the impact of drainage reuse on growth and development parameters of lettuce in two production systems: hydroponics (NFT system - Nutrient Film Technique) and soil.

In order to complement the study, nutrient and ecotoxicological analyses were also performed on the drainage and soil collected.

Materials & Methods

Location: greenhouse at Campus de Valção (FCUP/GreenUPorto).
Duration: 32 days (27 March - 27 June 2019).
Average greenhouse temperature of 19.2 °C.
Relative humidity of 68.9%.

Plants: *Lactuca sativa* var. capitata (Fig. 1).

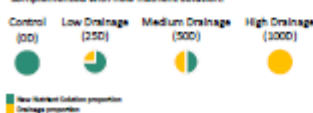
Two types of production systems (Fig. 2):

- Hydroponics (NFT)
- 12 systems (3 replicates x 4 treatments) composed by 2 lines of plants;
- 34 plants/replicate (7 plants/line);
- 1 reservoir (16 L) per system;
- 1 pump (300 L/h) per system;
- Fertigation: constant recirculation.

Soil – collected from a local grower using semi-open system

- 12 pots (3 replicates x 4 treatments);
- Pots' dimensions (200 x 100 x 120 mm);
- 2 plants/replicate;
- Fertigation: daily watering of soil humidity to 60% field capacity.

Four treatments were applied, consisting in different proportions of drainage (0, 25, 50, and 100%) complemented with new nutrient solution:



Acknowledgments/Notes
The authors would like to thank the FCUP and the I37 for funding, in the frame of the collaborative international research agreement (GreenUPorto) with the AGRI-UPES (European Union). This work was an integral part of the AGRI-UPES activities developed by the Water Challenge for a Changing World and Progression Initiative (Water4U).

Drainages were collected from a local grower using semi-open system.

- Two collections of 200 L each (drainage 1 and 2), which were homogenized in a reservoir before treatment preparation;
- Drainage 1 and drainage 2 were used in the first and second half of the experiment, respectively.

New nutritional solutions: prepared independently and according to a stock solution.

All treatments had the same electrical conductivity (EC defined by 1000) and pH (suitable for lettuce culture).



Fig. 2 - Hydroponics and soil trials

The replicates were randomly distributed within 3 blocks (Fig. 3).



Fig. 3 - Schematic diagram of the arrangement of trials and treatments

- Plant Analysis**
- Head diameter (HD)
 - Leaf area (LA)
 - Fresh Weight (FW)
 - Dry Weight
- Soil Analysis**
- pH
 - Electrical conductivity (EC)
 - % Organic Matter (OM)

Ecotoxicological assays using aquatic species exposed to the drainage and soil elutriates, following standard protocols:

- Raphidocelis subcapitata* (green microalgae) – growth inhibition assay (OECD 201, 2011) – 72 h exposure; continuous light conditions;
- Alivibrio fischeri* (bioluminescent bacterium) – Microtox® acute toxicity assay (0.1, 0.5% Test Protocol, Modermaster) – 30 min exposure.

Quantification of nutrients in the drainages

- Quantification of total nitrogen and phosphorus (colorimetric method, Hanna Int.);
- Quantification of total potassium, copper, zinc and magnesium (atomic absorption spectrometry method, GSC Scientific Equipment).

Results & Discussion

Soil Trial

None of the plant parameters showed significant differences, between the treatments and the control group.

The soil pH is not the most suitable for lettuce culture, at Table 1 shows (optimum pH: 6.5 - 7.2), being one of the possible justifications for the poor development of the plants in pots.

Soil	pH	EC (µS/cm)	OM (%)
Soil	8.2	0.8	3.8

Hydroponic Trial

There were no significant differences between the parameters obtained in the 0D and those obtained in the 25D and 50D treatments.

100D, when compared with 0D, caused a reduction of:

- Head diameter (20.0%) (Fig. 4b)
- Leaf area (40.7%) (Fig. 4c)
- Fresh Weight (25.5%) (Fig. 5).

The drainage could have had an inadequate nutrient profile, thus causing the detrimental effect observed in 100D. In 0D, 25D and 50D, the inclusion of fresh nutrient solution might have alleviated the effect of the drainage.

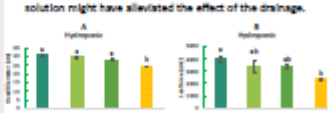


Fig. 4 - Head diameter (A) and leaf area (B) of lettuce plants exposed to different proportions of drainage (0, 25, 50 and 100%) in the hydroponics system. The values represent the average of the replicates (n = 12). Different letters indicate statistically significant differences (p < 0.05) through Tukey's test. (Hydroponics: 0D = control)



Fig. 5 - Fresh (FW) and dry weight (DW) of lettuce plants exposed to different proportions of drainage (0, 25, 50 and 100%) in the hydroponics system. The values represent the average of the replicates (n = 12). Different letters indicate statistically significant differences (p < 0.05) through Tukey's test. (Hydroponics: 0D = control)

Ecotoxicological Tests

The drainage samples were not toxic both for *A. fischeri* - highest observed effect < 20%, not being possible to calculate any EC (effective concentration) – and *R. subcapitata*. The soil elutriate showed high toxicity to *R. subcapitata* (EC₅₀ = 20.0%) (Fig. 6).

This suggests that reusing drainage in soil-grown crops can be harmful to the environment.

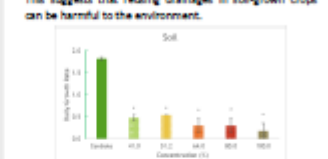


Fig. 6 - Daily growth rate of the microalgae (*R. subcapitata*), referring to growth inhibition assay using microalgae reared for the soil elutriate obtained considering the different concentrations tested. The values represent the mean of the replicates (n = 12). *** indicates statistically significant differences compared with the control (p < 0.05) using the Dunnett's test.

Nutrient Quantification

Table 2 - Amount of nutrients present in the drainage used in the fertigation in both ways.

Nutrients (µg/L)	Drainage 1		Drainage 2	
	0D	100D	0D	100D
Nitrogen	100.67	152.17	145.90	0.03
Phosphorus	0.03	0.13	196.80	
Potassium	46.67	200.20	216.96	0.06
Copper	0.06	0.46	22.70	
Zinc				
Magnesium				

The marked difference between the drainages collected (Tab. 2) can partly justify the differences observed in plant growth (e.g. nitrogen was much lower in the second half of the experiment).

Conclusions

The results of this study indicate good prospects for the implementation of closed systems using high percentages of drainage in fertigation cycles (e.g. 50%) without compromising yield. However, the results support the necessity to know the nutrient profile of the drainage to ensure that productivity is not affected by the shortage of some nutrient.

The assessment of the impact of reuse of drainage on nutritional quality and food safety is also important in order to infer more comprehensively on the appropriateness of drainage reuse.



WAGENINGEN
UNIVERSITY & RESEARCH

Sensoren voor meststoffen en gewasbeschermingsmiddelen (AGRINUPES)

Jos Belendonck, Erik van Os, Jim van Ruijven, Ellen Beerling



Achtergrond

Circulaire economie, duurzaamheid en concurrentievermogen zijn voor Europese telers synoniemen voor een hoge productie en kwaliteit en nul-emissie door efficiënt gebruik van water, meststoffen en gewasbeschermingsmiddelen. Om dat te kunnen waarborgen zullen toekomstige irrigatie- en bemestingsystemen ook gebruik gaan maken van waterzuiveringsinstallaties. Sensoren voor de concentraties van macro-nutriëntconcentraties, verontreinigingen en het natriumgehalte, zullen helpen om juiste management beslissingen te nemen.

Doelstelling

AGRINUPES beoogt de ontwikkeling van twee typen sensoren en zal de praktische toepassing daarvan demonstreren voor op demonstratiesites in Nederland, Spanje Portugal en Turkije. De eerste sensor is een ion-selectieve NPK sensor voor gebruik als online feedbacksysteem voor water- en nutriëntenbeheersystemen in de tuinbouw. De tweede is een biosensor voor insecticiden: één voor imidacoprid (een neonicotinoïde) en één voor pirimicarb (een carbamaat). Voor beide stoffen gelden in geheel Europa strikte normen. Voor imidacoprid heeft de EU aangekondigd om eind 2018 een toepassingsverbod af te kondigen voor de buitenteelten.

Aanpak

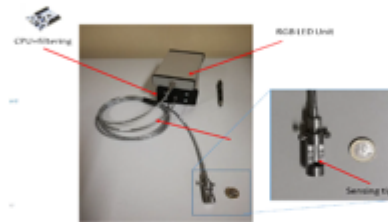
Wageningen UR Glastuinbouw richt zich op het testen en valideren van de sensoren onder Nederlandse tuinbouwcondities en de demonstratie van de sensoren in het IDC-Water in Bleiswijk. De sensoren worden getest op responstijd, meetbereik, selectiviteit, herhaalbaarheid, levensduur en invloed van temperatuur en pH. De eerste prototypen komen eind 2018 beschikbaar, en zullen dan in Zweden in het laboratorium worden getest. Daarna (in 2019) zullen de sensoren in Nederland getest worden. Ook zullen Best Management Practices voor deze sensoren worden ontwikkeld.

Toepassing door telers, waterschappen en toelevering

De NPK sensoren kunnen toegepast worden voor optimale toevoer en hergebruik van water en voedingsstoffen, waardoor schadelijke effecten op het milieu tot een minimum beperkt kunnen worden. De biosensoren kunnen voor een lozing aangeven of er wel of niet gezuiverd moet worden. Leveranciers kunnen de sensoren toepassen voor monitoring van waterkwaliteit en sturing (terugkoppeling) in hun fertigatie en zuiveringsystemen. Waterschappen kunnen de sensoren gebruiken om snel en goedkoop oppervlaktewater te controleren op de aanwezigheid van specifieke gewasbeschermingsmiddelen.

Sensoren voor NPK

De NPK sensoren maken gebruik van een UV technologie welke de veranderingen van de optische eigenschappen van het proceswater kunnen bepalen nadat dit in contact gebracht is met een specifieke chemische marker stof.



Figuur 1. Prototype van de NPK sensor.

Biosensoren voor insecticiden

De biosensoren zijn gebaseerd op de "Lateral Flow Technology". Hierbij moet een druppel van de bemonsterde vloeistof op een papieren strip in de sensorbehuizing aangebracht worden. Een streepje geeft aan of de sensor goed gewerkt heeft en het andere streepje of de concentratie van de specifieke stof boven de drempelwaarde ligt.



Figuur 2. Een mogelijke uitvoeringsvorm van de biosensoren.

Voorlopige resultaten

De verschillende toepassingsmogelijkheden zijn in kaart gebracht. Op basis van de waterstromensamenstellingen voor buiten- en kasteelten is een gewenste specificatie voor de sensoren gemaakt en vastgelegd in factsheets. De teams in Portugal en Turkije zijn daarmee aan de ontwikkeling van de sensoren begonnen. Er is daar vooral gewerkt aan de ontwikkeling van specifieke marker stoffen voor de detectie. Momenteel stelt Wageningen UR Glastuinbouw een begeleidingsgroep samen van geïnteresseerde potentiële gebruikers van de sensoren.

Financiering

AGRINUPES is een Europees ERA-NET project binnen het programma CoFund WaterWorks2015 en wordt in Nederland gefinancierd door het Ministerie van Economische Zaken.

Wageningen University & Research
Postbus 544, 6700 AP Wageningen
Contact: jos.belendonck@wur.nl
T + 31 (0)317 48 32 79
www.wur.nl/glastuinbouw





WAGENINGEN
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Sensoren voor meststoffen en gewasbeschermingsmiddelen (AGRINUPES)

Jos Balendonck, Erik van Os, Jim van Ruijven, Arjan Vroegop



Achtergrond

Circulaire economie, duurzaamheid en concurrentievermogen zijn voor Europese telers synoniemen voor een hoge productie, kwaliteit en nul-emissie door efficiënt gebruik van water, meststoffen en gewasbeschermingsmiddelen. Om dat te kunnen waarborgen zullen toekomstige irrigatie- en bemestingsystemen ook gebruik gaan maken van waterzuiveringsinstallaties. Sensoren voor nutriënten, gewasbeschermingsmiddelen, verontreinigingen en natrium, moeten helpen om juiste managementbeslissingen te kunnen nemen.

Doelstelling

AGRINUPES beoogt twee typen sensoren te ontwikkelen voor het meten van nutriënten en pesticiden in water om deze vervolgens onder praktische omstandigheden te testen en demonstreren op locaties in Nederland, Spanje, Portugal en Turkije. De eerste sensor, een ion-selectieve optische NPK-sensor, kan gebruikt worden als in-line meetstelsel voor de fertigatiecomputer. De tweede is een biosensor voor insecticiden: één voor imidacloprid (een neonicotinoïde) en één voor pirimicarb (een carbamaat). Voor beide stoffen gelden in geheel Europa strikte normen.

Aanpak

Partners in Portugal en Turkije ontwikkelen de sensor prototypen. Wageningen UR Glastuinbouw richt zich op het testen en valideren van de sensoren onder Nederlandse tuinbouwcondities en de demonstratie van de sensoren in het IDC-Water in Bleiswijk. Ook zullen Best Management Practices voor deze sensoren worden ontwikkeld.

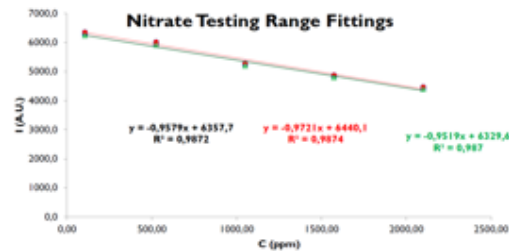
De sensoren worden getest op responstijd, meetbereik, selectiviteit, herhaalbaarheid, levensduur en invloed van temperatuur en pH. Een eerste prototype N-sensor is inmiddels beschikbaar. De testen in Zweden en Nederland gaan eind 2019 starten.

Sensoren voor NPK

De NPK sensoren gebruiken een technologie welke de veranderingen van de optische eigenschappen van het proceswater kunnen bepalen. De meet set-up bestaat uit een flow-cell, een (UV-VIS) lichtbron, fiber-optics, een spectrometer, en een PC met software voor data-acquisitie en analyse.



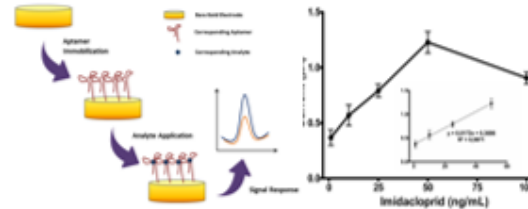
Wageningen University & Research
Business Unit Greenhouse Horticulture
Postbus 544, 6700 AP Wageningen
Contact: jos.balendonck@wur.nl
T + 31 (0)317 48 32 79
www.wur.nl/glastuinbouw



Testresultaten voor een standaard voedingsoplossing met variaties in nitraat (NO3).

Biosensoren voor insecticiden

De biosensoren werken met een markerstof die specifiek het gewasbeschermingsmiddel kan binden. In de test setup kan door het meten van een potentiaal de hoeveelheid stof die gebonden is bepaald worden. Eerste testen in het lab laten een lineair verband zien tussen de concentratie van imidacloprid en de gemeten potentiaal.



Werkingsprincipe en eerste test resultaat voor imidacloprid.

Toepassing door telers, waterschappen en toelevering

Telers kunnen de NPK sensoren toepassen voor optimale dosering en hergebruik van water en voedingsstoffen, waardoor schadelijke effecten op het milieu tot een minimum beperkt kunnen worden. De biosensoren kunnen aangeven of er wel of niet gezuiverd moet worden voor een lozing. Leveranciers kunnen de sensoren toepassen voor monitoring van waterkwaliteit en sturing (terugkoppeling) in hun fertigatie en zuiveringssystemen. Waterschappen kunnen de sensoren gebruiken om snel en goedkoop oppervlaktewater te controleren op de aanwezigheid van specifieke gewasbeschermingsmiddelen. Wageningen UR Glastuinbouw stelt een begeleidingsgroep samen van geïnteresseerde potentiële gebruikers van de sensoren.

Financiering

AGRINUPES is een ERA-NET project (Cofund WaterWorks2015) en wordt in Nederland gefinancierd door het Ministerie van LNV.

Annex 3. Minutes of UNG-meetings

Minutes UNG groups the Netherlands

UNG meeting at the “Annual WATER-day” in Bleiswijk (NL), Oct 5th, 2017 (M7).

Stakeholder consultation meeting to inform about the progress and to get feedback from the end-users. A presentation “AGRINUPES: Sensoren voor meststoffen en gewasbeschermingsmiddelen” was given. In total 35 persons attended the meeting among which about 10-15 growers. Contact was established with the water authority: Hoogheemraadschap Delfland and a bilateral meeting was setup to discuss the application of sensors (20-6-2018). The HHD is interested in the use of biosensors and is willing to test prototypes. The presentation was made available at: www.glastuinbouwwaterproof.nl/onderzoeken/bo_20_003_059_agrinupes_sensoren_voor_meststoffen_en_gewasbeschermingsmiddelen/.

UNG meeting at the “Annual WATER-day” in Bleiswijk (NL), Oct 4th, 2018 (M19).

Stakeholder consultation meeting to inform about the progress and to get feedback from the end-users. A poster was presented presentation “AGRINUPES: Sensoren voor meststoffen en gewasbeschermingsmiddelen” (2018-10-25-AgriNuPes-Waterevent.pdf). New stakeholders joined the UNG. In total the UNG existed out of 15 persons.



Figure 1. Poster presentation during Water Event (2018).

UNG meeting at the “Annual WATER-day” in Bleiswijk (NL), Oct 3rd, 2019 (M31).

Stakeholder consultation meeting to inform about the progress and to get feedback from the end-users. A poster was presented for 6 groups of about 10-12 persons (“Jos Balendonck, Erik van Os, Jim van Ruijven, Arjan Vroegop, 2019. AGRINUPES: Sensoren voor meststoffen en gewasbeschermingsmiddelen” file: 20191003-AgriNuPes-Waterevent2019.pdf). New stakeholders joined the UNG, bringing the total UNG members to 21 persons.

Remarkable was that one of the growers used a simple nitrate sensor to measure his nitrate in the nutrient solutions. He was interested in ion-specific measurement and explains: “I grow mainly cabbage plants on 7.5 hectares. In the cultivation of cabbage plants it is very important that we know exactly what the amounts of nitrogen (only NO₃) in our water is. We therefore have a separate control / injection for lime nitrate on the water unit. In recent years, we always checked our nitrogen emissions by sending samples to Green Agro (comment: external lab) and using the well-known nitrate measuring strips. Last year, after some own research on the

internet and at suppliers, we made changes here. We ended up at Horiba Laquatwin through a supplier (<https://www.horiba.com/laquatwin/en/lineup/index.html>).

The NO₃ handheld meter that we use works very simply and gives the NO₃ value in ppm quite accurately within a few seconds. With us, the two cultivators both have this sensor in their pocket as standard. We also saw that Horiba also offers the same sensors for other elements, but these are not yet important to us.

For the time being, because NO₃ must be controllable in our cultivation, we do not yet use our drain water and this (after BZG) is still discharged. We are currently installing closed floors and the plan is that we will start recirculating around 2022-2023. Therefore, an on-line NO₃ sensor is desired, as it is also used in the drinking water industries. This allows us to continuously monitor the amount of NO₃ entering the greenhouse”.



Figure 2. Presentation of poster and prototype NPK-sensor set-up at Water Event (2019).

Minutes UNG groups Sweden

Meeting information

29/3/2019 (9:30-11:30): Sånnagården, Klippan, Sweden (cucumber grower and café owner) (with vegetable production in focus), 34 growers.

4/4/2019 (13:00-15:30): Orevads Handelsträdgård, Hörby, Sweden (pot plant producer) (with potplant production in focus), 37 growers.

Agenda

Discussion regarding chemical residuals in surplus waters from greenhouses. New research in Sweden have shown that the chemicals from greenhouse production is till reaching the surface waters in levels far over acceptable concentrations. This was an information how to find and stop these leakages.

Information/discussions regarding AGRINUPES

During these two meetings information about the AGRINUPES project was given as an important future possibility to have better control of the residuals and nutrients in different greenhouse water flows. A very large interest was given for both the sensors and as soon as they are ready to be used several growers are interested to test and evaluate them. One of the main requests for the biosensors was that they should be as cheap as possible so that as many waterflows as possible could be measured. They also asked for the ability to have sensors for other active substances than pirimicarb and imidacloprid. No other specific questions or requests were made.



Figure 3. Information and coffee at Sånnagården (March 29, 2019).



Figure 4. Information and guidance at Orevads (April 4, 2019).

1st PORTUGUESE UNG MEETING, VAIRÃO, PORTUGAL | 24-09-2018

ATTENDEES: INESC TEC (6), FCUP (3), USN (10)

AGENDA

1. Opening session, José Boaventura and Susana Carvalho
2. Presentation of AGRINUPES project, José Boaventura
3. Optical sensors for NPK, Filipe Silva
4. The Portuguese case study: potential applications and future perspectives, Susana Carvalho and Miguel Santos
5. Robotic and automation for an efficient use of water, Filipe Santos
6. Round table and discussion with stakeholders, All



Figure 5. 'Round table' discussion with stakeholders during the Portuguese UNG Meeting (September 24, 2018).

CONCLUSIONS AND DECISIONS

José Boaventura and Susana Carvalho welcomed all participants and explained the aim of the meeting with the stakeholders entitled "1st User Network Group Meeting of the Soilless Cultivation Sector (in Portuguese)". The meeting was conducted in Portuguese.

Presentation of AGRINUPES project (José Boaventura): A brief presentation of the AGRINUPES project. Namely the goal of the project, organization, partners, website, among others.

Optical sensors for NPK (Filipe Silva): Introduction of the goals and some technical aspects of the NPK sensors to the stakeholders, focusing the tests and results achieved until the meeting.

The Portuguese case study, potential applications and future perspectives (Susana Carvalho and Miguel Santos): Work of FCUP in the AGRINUPES project. In particular, they presented the results of the characterization surveys performed with the growers in the beginning of the project and the results from the assessment on the impact of CRUS in water quality, as performed after drainage collection from three CRUS selected as case studies. Moreover, they explained the ongoing tasks and next steps to be performed by the FCUP team in AgriNuPes. All participants were informed that the results from the general characterization of the Portuguese soilless production systems could be consulted in the Project's website, namely in the Deliverable 5.1. (in English) and in an article (in Portuguese) published in the proceedings of the international conference "1st Portuguese-Brazilian Congress on Horticulture", held in Lisbon in November 2017.

Robotic and automation for an efficient use of water (Filipe Santos): A more general overview of the INESC TEC role in projects related with agriculture and water in particular.

Round table and discussion with stakeholders (All)

After the presentations, a discussion with the stakeholders took place in the meeting. The discussion focused the following aspects: interest in what is being developed in the project; possible additions to the project; perspective on the sector; main bottlenecks of the sector; needs from the companies/growers; technologies that could be introduced in the sector.

From the discussion during the meeting, it was possible to conclude that the stakeholders presented in the meeting considered the NPK sensors and biosensors an important contribute to the sector. Furthermore, they pointed that sensors for secondary macronutrients as calcium or magnesium would also be important. Besides the monitoring of nutrients in the drainage water, the stakeholders considered important to develop technologies that guarantee the water quality for proper recirculation. Also, aspects related with energy consumption and the use of alternative sources of energy were mentioned as a topic to develop.

Minutes UNG groups Turkey

Thematic Workshop on 'Water management and uses – nexus with climate and food', Dushanbe 24-26 June 2019

The EU-Central Asia Network for Water Science and Technology -supervised by European Commission- convened a thematic workshop on 'Water management and uses – nexus with climate and food' on 24-26 June 2019 in Dushanbe, Tajikistan. During the event Central Asian experts had a chance to exchange ideas on a selection of successful RDI practices related to hydrology and water availability; improved irrigation technologies; innovative agro-business and tolerant crop development; Information and Communication Technologies (ICT) and earth observation solutions. Osman Tikansak from Turkish Water Institute (SUEN) were among the panelists to virtually present AGRINUPES at the workshop. A few interesting questions related to usage instructions and cost of AGRINUPES sensors were raised by the audience.



Figure 6. Photos taken at the Thematic Workshop at Dushanbe (2019).

UNG meeting with local stakeholders in Konya



Figure 7. UNG meeting with local stakeholders in Konya.

UNG meeting in Konya with local stakeholders

Oct 10th, 2018 (M19)

A meeting was held to inform relevant stakeholder about the project in detail, especially focusing on sensors to be developed and to get an initial feedback. In total 13 experts from irrigation unions, agricultural cooperatives, agricultural research institutes, provincial agriculture and water related authorities attended the meeting. The participants were interested in testing the sensors once they are fully developed. Overburdened with implementation problems of relevant regulations, authorities implied sensors could help overcome some of the problems faced with regards to unsustainable farming practices. Participants also noted that there is need for legislative support, strict inspections and robust incentives/penalty mechanisms, in order to fully benefit from the developed monitoring tools.



Figure 8. UNG meeting with local stakeholders in Konya (2018).

Another UNG meeting had been planned for the demonstration of sensors in the field study area, but this could not be accomplished due to pandemic outbreak. Instead, UNG group and a few farmers were interviewed through a short survey in order to get their opinions on current agricultural practices (bottlenecks, wise use of agricultural inputs, etc.), gaps in current water and agriculture related policies, and how these difficulties could be overcome by utilization of newly developed sensors.