# D7.1.2 Demonstration Report

2nd Year Progress

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## 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 |

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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. This public Demonstration Report describes the progress on the demonstration activities. It contains the collected minutes of User Network Groups (UNG) meetings and summaries of Demonstration Reports and related dissemination activities in the case studies. It is an evolving document with milestones at M12, M24 and M45. Demonstration is expected to start from month 18 on, once working prototypes of sensors have become available. This second year report (M24) gives the progress until the moment that first prototypes were expected to be shown. As the project was extended until M45, this report reflects the situation at M36 (first quarter of 2020).

All 4 Use Cases (Portugal, The Netherlands, Turkey and Sweden) have started their activities and have set-up User Network Groups. Stakeholders have been informed about the targets of the AgriNUpes project via national websites, held group meetings, poster presentations, magazine articles, and international scientific conferences. The prototype NPK-sensor have become available, and for Portugal and The Netherlands the prototype 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 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 was postponed to the third reporting year.

# 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 is expected to start from month 18 on (once working prototypes of sensors have become available). The other two tasks (T7.2 and T7.3) run during the whole project execution (M1-M36).

In the second year the first prototypes for the NPK-sensor and biosensors have become available only to a much later moment then planned. As such, this second-year report was issued much later than planned and reports the status of the project demonstrations until the first quarter of 2020. The 3rd year report (version 3) will conclude all demonstrations at the end of the project (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 | 2nd 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 | 3rd 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 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.

# 3. Conclusion

All 4 Use Cases (Portugal, The Netherlands, Turkey and Sweden) have started their activities and have set-up User Network Groups. Stakeholders have been informed about the targets of the AgriNUpes project, via national websites, held group meetings, poster presentations, magazine articles, and international scientific conferences. The prototype NPK-sensor have become available, and for Portugal and The Netherlands the prototype 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 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 was postponed to the third reporting year.

# Annexes

## Annex 1: Summary of Case Study dissemination activities

- **User Network Group (PT):**
  - AgriNupes page at the Water JPI website (M1, INESCTEC, 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/
  - Spanish website at Ritec (http://www.ritec.es/sistemas-riego-fertirrigacion/proyectos-de-investigacion.html
  - User Network Group (PT) established 24-9-2018.
  - Poster presentation in Agri Innovation Summit 2017.
  - 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)
  - 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
  - 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 Condo, 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).
  - AGRINUPES Prototype at Business2Sea, 2019. Congress Centre Alfândega do Porto, Portugal14th-16th November 2019.

- **User Network Group (NL):**
  - 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-nutrienten-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-nutrienten-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://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).

- **User Network Group (TR):**
  - 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.

- **User Network Group (ES):**
  - First User Network Group Meeting in Spain (RITEC). Madrid, Spain (Fuit Attraction), 23rd October 2018.

- **User Network Group (SE):**
  - 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/.

- A technical demonstration of the sensors was also planned this spring in the beginning of April but has been postponed to august due to Covid-19. However, if this will be completed or not is not decided yet due to the unknown situation this autumn.

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.* |
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## 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.

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

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## 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:**
- Otimização da fertirrega
- Redução do impacte 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

Tipos de resposta:
- Simples (1 opção)
- Múltipla (+ que 1 opção)
- Aberta

**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

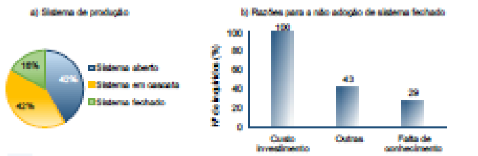



Figura 1: Frequência (%) de resposta no que respeita (a) ao uso da solução nutritiva (n=12) (sistema aberto: drenagem livre; sistema em cascata: drenagem recolhida e reutilizada em culturas secundárias; sistema fechado: recirculação da drenagem na cultura principal), e (b) aos motivos para a não adoção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

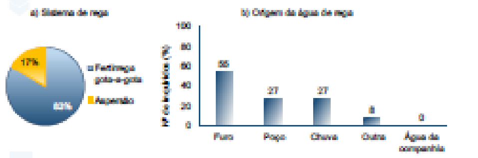



Figura 2: Frequência relativa (%) do tipo de sistema de rega usado (a) e frequência (%) da origem da água de rega (b) dos produtores inquiridos (n=12).

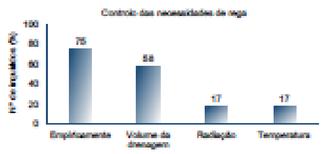



Figura 3: Frequência (%) do método usado, pelos produtores inquiridos (n=12), para o controlo das necessidades de rega.

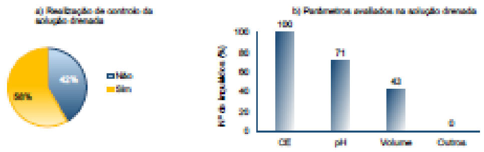



Figura 4: Frequência relativa (%) de controlo da solução nutritiva drenada (a) e frequência (%) dos parâmetros avaliados (b) pelos produtores inquiridos. CE: condutividade elétrica.

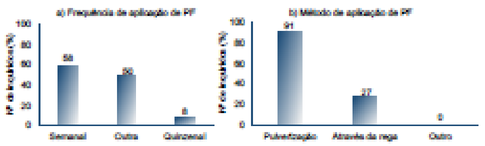



Figura 5: Frequência (%) de aplicação de produtos fitofarmacêuticos (PF) (a) e do método de aplicação utilizado (b) pelos produtores inquiridos (n=12).

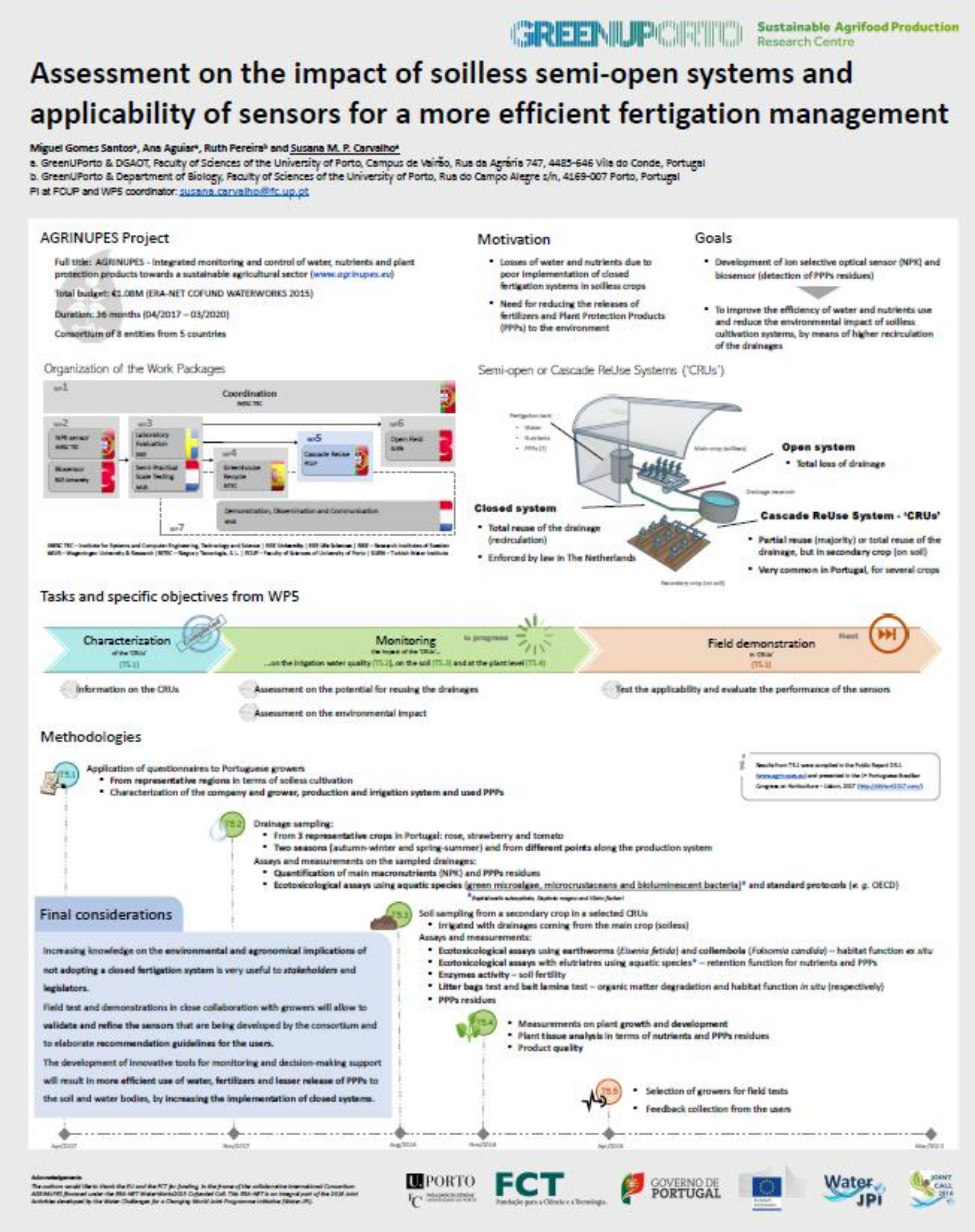
## Conclusões

- 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 WaterJPI/002/2015, no âmbito do consórcio colaborativo internacional AGRINUPES, financiado pelo ERA-NET WaterWorks2015. Este ERA-NET é parte integrante das Atividades Conjuntas 2016 desenvolvidas pelo 'Water Challenges for a Changing World Joint Programme Initiative (Water JPI)'.

Poster 2 (PT)


GREENUPORTO
Sustainable Agrifood Production Research Centre
Assessment on the impact of soilless semi-open systems and applicability of sensors for a more efficient fertigation management
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PI at FCUP and WP5 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 COFUND WATERWORKS 2015)
Duration: 36 months (04/2017 – 03/2020)
Consortium of 8 entities from 5 countries
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
Organization of the Work Packages
Coordination
Semi-open or Cascade ReUse Systems ('CRUs')
Open system
Total loss of drainage
Closed system
Total reuse of the drainage (recirculation)
Enforced by law in The Netherlands
Cascade ReUse System - 'CRUs'
Partial reuse (majority) or total reuse of the drainage, but in secondary crop (on soil)
Very common in Portugal, for several crops
Tasks and specific objectives from WP5
Characterization
Monitoring
...on the irrigation water quality (T5.2), on the soil (T5.3) and at the plant level (T5.4)
Field demonstration
Information on the CRUs
Assessment on the potential for reusing the drainages
Assessment on the environmental impact
Test the applicability and evaluate the performance of the sensors
Methodologies
T5.1
Application of questionnaires to Portuguese growers
From representative regions in terms of soilless cultivation
Characterization of the company and grower, production and irrigation system and used PPPs
T5.2
Drainage sampling:
From 3 representative crops in Portugal: rose, strawberry and tomato
Two seasons (autumn-winter and spring-summer) and from different points along the production system
Assays and measurements on the sampled drainages:
Quantification of main macronutrients (NPK) and PPPs residues
Ecotoxicological assays using aquatic species (green microalgae, microcrustaceans and bioluminescent bacteria)* and standard protocols (e. g. OECD)
T5.3
Soil sampling from a secondary crop in a selected CRUs
Irrigated with drainages coming from the main crop (soilless)
Assays and measurements:
Ecotoxicological assays using earthworms (Eisenia fetida) and collembola (Folsomia candida) – habitat function ex situ
Ecotoxicological assays with elutriates using aquatic species* – retention function for nutrients and PPPs
Enzymes activity – soil fertility
Litter bags test and bait lamina test – organic matter degradation and habitat function in situ (respectively)
PPPs residues
T5.4
Measurements on plant growth and development
Plant tissue analysis in terms of nutrients and PPPs residues
Product quality
T5.5
Selection of growers for field tests
Feedback collection from the users
Final considerations
Increasing knowledge on the environmental and agronomical implications of not adopting a closed fertigation system is very useful to stakeholders and legislators.
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.
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GREENUPORTO Sustainable Agrifood Production Research Centre

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

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## Introduction

- Soilless 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.

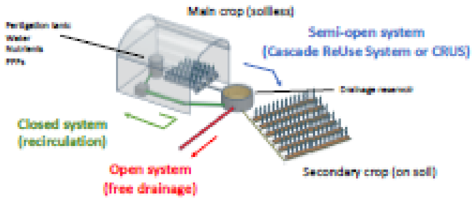


Figure 1. Schematic representation of the types of semi-hydroponic systems, regarding drainage reuse.

## AGRINUPES

- The Project AgriNuPes (www.agrinupes.eu) is developing a NPK optical sensor and a biosensor (detection of PPPs) to:
  - Improve the fertigation management in soilless cultivation;
  - Increase the implementation of closed systems;
- Consortium of 8 entities from 5 countries;
  - FCUP (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:

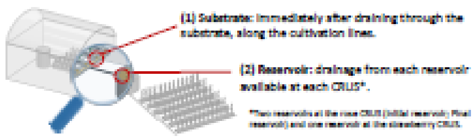


Figure 2. Schematic representation of the sampling points where the drainages from CRUS were collected.

- Ecotoxicological assays using aquatic species and standard protocols:
  - *Raphidocelis subcapitata* (green microalga) – growth inhibition assay (OECD 201, 2011);
  - *Daphnia magna* (microcrustacean) – immobilization assay (OECD 202, 1984);
  - *Aliivibrio fischeri* (bioluminescent bacteria) – Microtox® acute toxicity assay (81,9% 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

- *R. subcapitata* growth was inhibited only by the drainages from the rose CRUS (Table 1);
  - Probably due to the higher PPPs residues in the drainages 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 residues 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 drainages 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 | | *R. subcapitata* 72h-$EC_{20}$ (%)[a] (95% CI) | *D. magna* 48h-$EC_{50}$ (%)[b] (95% CI) | *A. fischeri* HE (%)[c] |
|---|---|---|---|---|
| Rose CRUS | Substrate | 63 (57-70) | 8 (nc) | 19 |
| | Initial Reservoir | Non-toxic | 21 (11-28) | -11 |
| | Final Reservoir | Non-toxic | 18 (9-26) | -24 |
| Strawberry CRUS | Substrate | Non-toxic | 48 (43-52) | -47 |
| | Reservoir | Non-toxic | 11 (9-12) | -41 |

[a] 72h-$EC_{20}$ is the effective concentration of drainage at which growth of *R. subcapitata* was inhibited by 20%, after 72 h of exposure.
[b] 48h-$EC_{50}$ is the effective concentration of drainage that caused immobilization in 50% of the cladocerans *D. magna*, after 48 h of exposure.
[c] HE is the highest effect on the bioluminescence of *A. fischeri*. Negative values indicate stimulus, rather than inhibition.
Non-toxic: maximum effect <20% | nc: not calculated.

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

| Drainages | | Metalaxyl-M (µg/L) | Pyraclostrobin (µg/L) | Azoxystrobin (µg/L) | Dimethomorph (µg/L) | Difenoconazole (µg/L) | Myclobutanil (µg/L) | Boscalid (µg/L) |
|---|---|---|---|---|---|---|---|---|
| Rose CRUS | Substrate | 2.14 | 0.09 | 0.72 | 12.1 | 0.272 | 1.30 | 0.93 |
| | Initial Reservoir | 0.45 | 0.14 | 0.23 | 300.0 | 0.321 | 0.73 | 1.29 |
| | Final Reservoir | 0.20 | 0.17 | 0.26 | 36.1 | 0.396 | 1.64 | 2.89 |
| Strawberry CRUS | Substrate | 0.03 | 0.17 | 0.18 | 1.2 | <0.005 | 0.12 | 5.36 |
| | Reservoir | 0.01 | 0.05 | 0.17 | 36.2 | <0.005 | 0.14 | 3.97 |

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 ± 0.7$^{a}$ | 1.6 |
| | Initial Reservoir | 121.3 ± 6.4 | 34.7 ± 0.9$^{b}$ | 1.5 |
| | Final Reservoir | 140.7 ± 4.1 | 28.7 ± 0.2$^{c}$ | 1.4 |
| Strawberry CRUS | Substrate | 86.0 ± 12.1 | 20.6 ± 0.6$^{d}$ | 1.5 |
| | Reservoir | 51.3 ± 3.7 | 14.8 ± 0.2$^{e}$ | 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 soilless 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 EU and the FCT for funding, in the frame of the collaborative international Consortium AGRINUPES financed under the ERA-NET WaterWorks2015 Cofunded Call. This ERA-NET is an integral part of the 2016 Joint Activities developed by the Water Challenges for a Changing World Joint Programme Initiative (Water JPI).*

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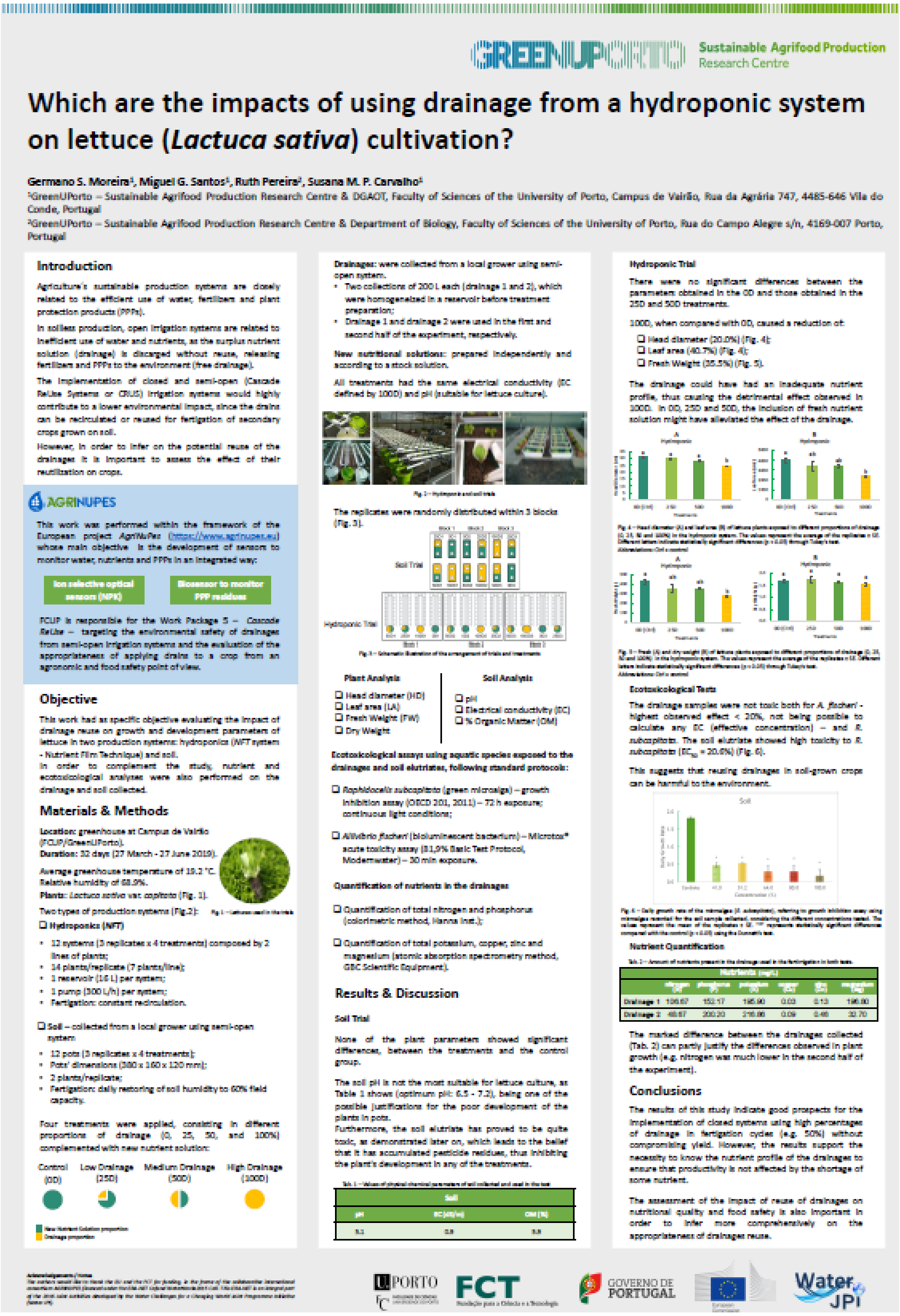

GREENUPORTO Sustainable Agrifood Production Research Centre

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

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## Introduction

Agriculture's sustainable production systems are closely related to the efficient use of water, fertilizers 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 discarged without reuse, releasing fertilizers 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 drainages it is important to assess the effect of their reutilization on crops.

AGRINUPES

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:

- Ion selective optical sensors (NPK)
- Biosensor 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 Vairão (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;
  - 14 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 (380 x 160 x 120 mm);
  - 2 plants/replicate;
  - Fertigation: daily restoring 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:

Control (0D) | Low Drainage (25D) | Medium Drainage (50D) | High Drainage (100D)

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

- Two collections of 200 L each (drainage 1 and 2), which were homogenaized 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 100D) and pH (suitable for lettuce culture).

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

**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 drainages and soil elutriates, following standard protocols:**

- ❑ *Raphidocelis subcapitata* (green microalga) – growth inhibition assay (OECD 201, 2011) – 72 h exposure; continuous light conditions;
- ❑ *Aliivibrio fischeri* (bioluminescent bacterium) – Microtox® acute toxicity assay (81,9% Basic Test Protocol, Modernwater) – 30 min exposure.

**Quantification of nutrients in the drainages**

- ❑ Quantification of total nitrogen and phosphorus (colorimetric method, Hanna Inst.);
- ❑ Quantification of total potassium, copper, zinc and magnesium (atomic absorption spectrometry method, GBC 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, as Table 1 shows (optimum pH: 6.5 - 7.2), being one of the possible justifications for the poor development of the plants in pots.

Furthermore, the soil elutriate has proved to be quite toxic, as demonstrated later on, which leads to the belief that it has accumulated pesticide residues, thus inhibiting the plant's development in any of the treatments.

| Soil | | |
|---|---|---|
| pH | EC (dS/m) | OM (%) |
| 5.1 | 0.9 | 5.8 |

**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. 4);
- ❑ Leaf area (40.7%) (Fig. 4);
- ❑ Fresh Weight (35.5%) (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.

**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* ($EC_{50}$ = 20.0%) (Fig. 6).

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

**Nutrient Quantification**

| | Nutrients (mg/L) | | | | | |
|---|---|---|---|---|---|---|
| | nitrogen (N) | phosphorus (P) | potassium (K) | copper (Cu) | zinc (Zn) | magnesium (Mg) |
| Drainage 1 | 106.67 | 152.17 | 185.90 | 0.03 | 0.13 | 196.80 |
| Drainage 2 | 48.67 | 200.20 | 216.86 | 0.09 | 0.48 | 32.70 |

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 drainages to ensure that productivity is not affected by the shortage of some nutrient.

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

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Poster 5 (NL)

WAGENINGEN
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# Sensoren voor meststoffen en gewasbeschermingsmiddelen (AGRINUPES)

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

AGRINUPES

## 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 bemestingssystemen 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 imidacloprid (een neonicotinoïde) en één voor pirimicarb (een carbamaat). Voor beide stoffen gelden in geheel Europa strikte normen. Voor imidacloprid heeft de EU aangekondigd om eind 2018 een toepassingsverbod af te kondigen voor de buitenteelten.

## Aanpak

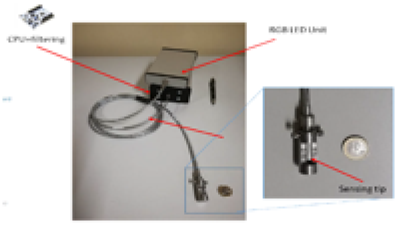
Wageningen UR Glastuinbouw richt zich op het testen en valideren van de sensoren onder Nederlandse tuinbouwcondities en de demonstratie van de sensoren in het IDC-Water in Bleiswijk. De sensoren worden getest op responstijd, meetbereik, selectiviteit, herhaalbaarheid, levensduur en invloed van temperatuur 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 zuiveringssystemen. 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.

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Poster 6 (NL)

WAGENINGEN
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# Sensoren voor meststoffen en gewasbeschermingsmiddelen (AGRINUPES)

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

AGRINUPES

## 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 bemestingssystemen 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 meetsysteem 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.

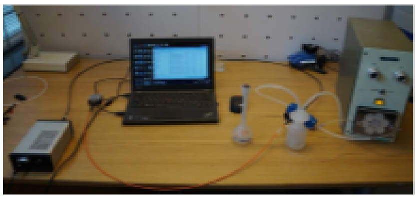
## Aanpak

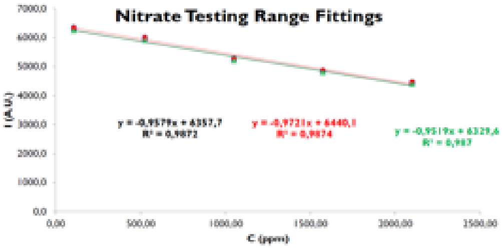
Partners in Portugal en Turkije ontwikkelen de sensor prototypen. Wageningen UR Glastuinbouw richt zich op het testen en valideren van de sensoren onder Nederlandse tuinbouwcondities en de demonstratie van de sensoren in het IDC-Water in Bleiswijk. Ook zullen Best Management Practices voor deze sensoren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

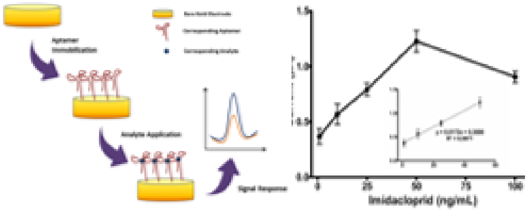





Testresultaten voor een standard voedingsoplossing met variaties in nitraat (NO3).

## 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.

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## 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 3th, 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-Waterevnet2019.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).*

**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

**CONCLUSIONS AND DECISIONS**

José Boaventura and Susana Carvalho welcomed all participants and explained the aim of the meeting with the stakeholders entitled "1º Encontro da rede de stakeholders da fileira das culturas protegidas sem solo". 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 tests to the drainage water collected in some semi-closed system producers.

**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 is 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 5. Photos taken at the Thematic Workshop at Dushanbe (2019).*

**UNG meeting with local stakeholders in Konya**


*Figure 6. UNG meeting with local stakeholders in Konya.*

**UNG meeting in Konya with local stakeholders**

Oct 10th, 2018 (M19)

Stakeholder meeting to inform about the project in detail, especially focusing on sensors to be developed and to get feedback from the end-users. 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 7. UNG meeting with local stakeholders in Konya (2018).*