Development of a technology for the monitoring of all the slurry from a farm on an annual basis in order to determine its nutrient content (N, P, K) using NIR (near-infrared) technology and its volume using sensors

Summary

This project consists of developing and validating the operation of a tool capable of providing a more accurate measurement of nitrogen, phosphorus and potassium generated in each farm, thereby more accurately establishing the amount of nutrients applied to the soil in the farm. The development of a technology based on NIRS (near-infrared spectroscopy) sensors linked to the GPS tank monitoring system currently in place would allow complete monitoring and quantification of the distribution of the application of nutrients from livestock waste throughout Catalonia and especially the quantity of N, P, and K generated at each farm.

The project therefore involves: (i) the implementation and validation of the use of IR sensors together with optical flowmeters as reliable and accurate measurement tools to ascertain the amount of nutrients (N, P, K) generated in livestock farms and (ii) the creation of an application compatible with the current the Catalan Government platform to incorporate the monitoring of nutrients generated and applied to the soil throughout the region.

Objectives

The main objective of the project is therefore to improve the current system of monitoring, quantification and distribution of nutrients contained in slurry. To do this, it proposes the development of a robust and adaptable NIRS technology-based system to measure the N, P and K content of slurry in real time and obtain information on the quantity of nutrients generated at each livestock farm and where they have been transported and applied.

Description of the actions carried out in the project

1.- Identification, purchase and assessment of the viability of IR sensors and optical flowmeters available on the market.

This task involved collecting the different options of IR sensors and optical flowmeters available on the market. Based on the technical specifications of the different options available and the estimates obtained, the most appropriate devices were selected, evaluating both technological and financial considerations.

.-2 Design, construction and validation of the sampling system and validation of the system to quantify nutrients in slurry ponds and implementation to analyse and validate its application during the tank filling process.

A sampling system was designed and built and NIRS technology validated by carrying out 12 samplings with different types of slurry (from mothers, closed cycles and fattening) and different farms. The following actions were carried out in each field test to evaluate the technical feasibility of the system:

- Monitoring the volume of slurry in the tank through level measurements (before and after loading the slurry into the tanker truck).

- At each sampling, five samples were taken from the uptake suction to analyse nutrient content in the laboratory (N: P: K). These data were compared to the nutrient content estimated by conductivity and IR measurement, according to the corresponding calibrations.
- In each test, the volume captured by the tank provided by the flowmeter incorporated in the NIRS measuring station was measured.

3.- Construction of a real-time data transmission platform.

The monitoring and data recording system was linked to an online platform designed for real-time GPS-controlled transmission of the slurry tank loading and unloading points and the nutrients contained in them to the current Catalan Government portal.

4.- Determination of the technical and financial viability of the system in relation to the quality of the data obtained.

Once the performance of the acquired NIRS had been assessed, the reliability of the nutrient content data provided by the IR sensor and those estimated from conductivity measurements was studied with respect to the lab results and a financial estimate was made.

Final results and practical recommendations

Out of all the NIRS options available, the John Deere Harvestlab3000 system was chosen for the project and sampling equipment was developed and built (Figure 1A), adaptable to the NIR measuring station (Figure 1B).

Figure 1. Photo of the sampling equipment connected to the tank and the NIRS (left) and the stationary equipment (right)

Apart from providing results for total solids and ammonium, which cannot be obtained from the conductivity lines of the Ministry of Agriculture, Livestock, Fisheries and Food, the results show that the NIRS offers better accuracy for the other parameters (nitrogen, phosphorus and potassium). Although the relative error in most readings is between 10 and 20% (Figure 2), it should be noted that it is greater than 20% in the case of the conductivity line. The parameter with the poorest reading is phosphorus; however, this cannot be correlated to electrical conductivity, so the Ministry offers default values based on type of slurry. This is why the error is much higher for Ministry figures.

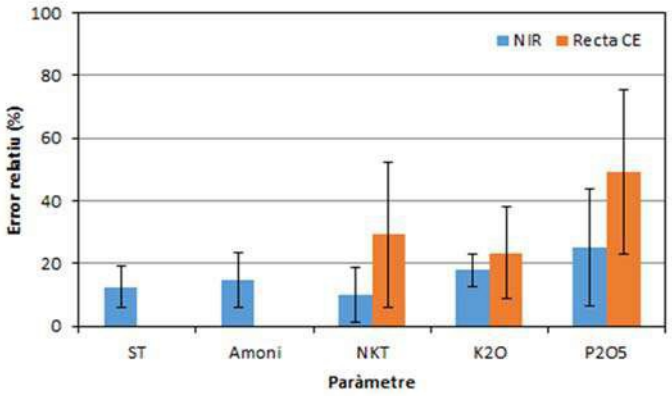

Figure 2. Relative error for each of the parameters analysed with the NIRS and with the Ministry conductivity line.

It was decided to work with the company Triskel Telecom to transmit the slurry readings in real time to the Ministry, bearing in mind that the tank used for sampling had the company's GPS installed, which appears as a benchmark on the Ministry website. The company has a platform for managing such operations, so Triskel can include the NIRS reading on its own online platform to send it in the same way to Ministry. Thus, the aforementioned partner developed the hardware and software necessary for the transmission of the slurry measuring station data.

Figure 3. The Triskel Telecom online platform graphic interface, showing the details of a tanker truck slurry load, includes the data extracted from the NIRS measuring station reading.

The results obtained are conclusive in determining that the NIRS is technically feasible, as it provides good readings for nutrients while improving the accuracy of the conductivity meter, which is the technology currently used by tankers transporting slurry. However, financially, as long as there is no stricter legislation on accuracy in the application of nutrients to the soil, the conductivity meter is a more affordable option as the investment could be only 25% of the cost of investing in NIRS. Nevertheless,

compared to chemical fertilisers, the NIRS becomes economically viable at the fertilisation of 100 ha of land with a minimum return on investment of 12 years.

Conclusions

- The NIRS measuring station validated in this project provides **satisfactory results** with respect to the conductivity meter.
- The NIRS is capable of determining the nutrient content of slurry with a **mean relative error of less than 20%**, except in the case of P_2O_5, where the mean relative error is approximately
- 25%.
  The software for the NIRS measuring station combined with the monitoring and data transmission system devised by Triskel Telecom, permits **real-time tracking** of both the **amount**
- **of nutrients generated by each farm** and **point where** these nutrients are applied to the soil.
  The financial analysis shows that as long as there are no further legal restrictions on the application of slurry to the soil in search of more accuracy than that offered by the conductivity meter, the latter will provide a cheaper alternative, as the cost of investment is only 25% that of the NIRS.

Leader of the Operational Group

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Subject area(s) of application

☐	Agricultural production system
☐	Agricultural practice
☒	Agricultural equipment and machinery
☐	Livestock farming and animal welfare
☐	Vegetable production and horticulture
☐	Landscape / Territorial management
☐	Pest and disease control
☒	Fertilisation and nutrient management
☐	Soil management
☐	Genetic resources
☐	Forestry
☐	Water management
☐	Climate and Climate Change
☐	Energy management
☒	Waste and by-product management
☐	Biodiversity and environmental management
☐	Food quality/processing and nutrition
☐	Supply chain, marketing and consumption

☐	Competitiveness and agricultural and forestry diversification
☐	General

Geographical area(s) of application

PROVINCE(S)	REGION(S)
Barcelona, Girona, Lleida and Tarragona	All (Catalonia)

Dissemination of the project (publications, seminars, multimedia, etc.)

Project dissemination is based on publications on social media by CT Beta and the Plana de Vic Cooperative accounts. Entries were made in the University of Vic (UVic) media, such as Apunt (UVic Information Blog). And it has also been publicised through talks with members of the Plana de Vic Cooperative.
The results are being studied for scientific publication in one of the international journals specialising in the treatment and application of livestock waste, as well as in soil fertilisation.

More information on the project

PROJECT DATES	TOTAL BUDGET
Starting date (month-year): June 2018	Total budget: €195,625.00
Completion date (month-year): September 2020	DARP funding: €78,054.37
Current status: Executed	EU funding: €58,883.13
	Own funding: €58,687.50

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Order ARP/133/2017 of 21 June, approving the regulatory bases for grants for cooperation for innovation by promoting the creation of European Association for Innovation operational groups in the areas of agricultural productivity and sustainability and the execution of innovative pilot projects by those groups, and Resolution ARP/1868/2017, of 20 June, announcing the call for the grant.

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