Desarrollo de Nuevas Tecnologías que impulsan Avances en Agricultura de Precisión para optimizar insumos y reducir la huella ambiental.

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Resumen:

Avances en el sector de la agrotecnología ofrecen la oportunidad de que los sistemas agroalimentarios contribuyan a conseguir objetivos políticos mundiales como lograr sistemas de carbono neto cero y reducir la huella ambiental mediante la eliminación de emisiones nocivas y el aumento de la biodiversidad. Una serie de sensores puede detectar la salud y el estrés de los cultivos debido a amenazas bióticas y abióticas. La detección precoz permite tomar medidas adecuadas antes de que el rendimiento de los cultivos se vea afectado o la presión de plagas y enfermedades no pueda controlarse sin el uso de pesticidas sintéticos. La tecnología de detección utiliza técnicas de imagen o detección de compuestos volátiles mediante e-nose y diagnóstico molecular en tiempo real, identificando patógenos vegetales recogidos en muestras de aire. Los datos generados por estas tecnologías proporcionan a los agricultores información temporal y espacial. Permite identificar plantas individualmente, incluso desde satélite, lo que posibilita aplicar con precisión fertilizantes y pesticidas, directamente a la planta o a la zona de cultivo afectada con técnicas de pulverización controladas a partir utilizando los datos adquiridos.

Palabras clave: Agricultura de precisión, aplicación de precisión, carbono neto cero, conectividad, sostenibilidad

Developing of New Technologies Driving Advances in Precision Agriculture to optimise inputs and reduce environmental footprint.

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Abstract:

Technological advances in the agri-tech sector offer the opportunity for food production systems to contribute to achieving global policy aims such as achieving net zero carbon systems and reducing environmental footprint through eliminating harmful emissions and increasing biodiversity. A range of sensors can detect crop health and stress due to biotic and abiotic threats, often with an early detection which permits appropriate action to be taken before crop yield is affected or pest and disease pressure cannot be controlled without the use of synthetic pesticides. Detection

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technology uses imaging techniques, often beyond the visible spectrum, detection of volatile compounds using e-nose techniques and real time molecular diagnostic techniques to identify plant pathogens collected in air samples. The data generated by such technologies relies on connectivity of the hardware and subsequent analytical processes to provide growers with temporal and spatial information. It is possible to identify plant locations with great accuracy, even with satellite systems, which permits precision application of crop inputs, such as fertilisers and pesticides, directly to the plant or crop area as required. Spray application techniques can now treat individual plants, both crop and weeds, using data acquired to control the flow to individual nozzles.

Key Words: Precision agriculture, precision application, net zero carbon, connectivity, sustainability

1. INTRODUCTION

Technology is advancing in the agricultural sector, from automated sensing with ground based systems to remote satellite systems, with connectivity ranging from simple Bluetooth networks to 5G and LoRaWAN (Long Range Wide Area Networks). Early detection systems were developed for tree and bush fruit crops with simple detection of trees and canopy to allow the sprayer to be turned on or off so that only foliage was treated as the sprayer passed along the rows. This was introduced to reduce the pesticide waste but also was part of an approach to reduce spray drift with orchard airblast sprayers by preventing spray droplets being released above the canopy and so prone to drift. The detection of weeds between the rows of crops was also another early development allowing targeted spray application or mechanical weeding. Precision agriculture relies on an appropriate detection technique to identify and locate the area needing treatment, followed by an application technique or treatment system to rectify the problem. Application techniques have developed with spray nozzle and delivery systems and weeds can be removed mechanically or destroyed by heat from a range of sources including electrical currents.

2. METHOD/DEVELOPMENT OF INNOVATION EXPERIENCE

2.1. Weed sensing technology

The use of RGB (Red Blue Green) imaging has been common to detect the location of crop foliage or weeds and volunteer plant such as potatoes in a cereal crop. Biller et al. developed one of the initial systems which looked at location specific spraying of herbicides, but using electronic sensors to identify and locate the weeds. The sensors being able to distinguish the plants green colour and the difference with the background soil.

Miller et al. (2012) was successful in developing a system for the spot treatment of volunteer potatoes in vegetable crops with real-time identification and treatment based on a conventional hydraulic boom sprayer. Gerhards et al. (2022) recently reviewed the advances that have been made with weed identification in crops to allow for precision application and treatment.

2.2. Canopy sensing technology

The characterisation of crop canopies is critical to allow the correct dose and spray volume to be applied to the appropriate parts of the crop or plant. Great advances have been made with tree crops in particular to prevent the waste of pesticides by spraying the whole orchard in a uniform manner. The development of Tree Row Volume (TRV) and Tree Wall application allows to dose and spray volume to be matched to leaf area index or foliar density. However, by detecting the location of trees and foliage the sprayer nozzles can be controlled, so reducing the total amount of spray needed to treat the whole orchard. Giles et al. describes early work with orchard spraying using electronic sensing of target characteristics. A simple approach to orchard spraying with the modern smaller trees was developed using the tunnel sprayer, which reduced the spray volume needed and reduced the amount of drift, an important consideration for environmental safety. The sprayer has a canopy which covers the crop with spray nozzles directed at the crop, and collects any spray passing through the foliage in the canopy on the opposite side. Pergher et al. (2013) have assessed the spray deposition on the crop and the extent to which the spray liquid can be recycled in vineyards with such an air-assisted tunnel sprayer.

2.3. Pest and disease detection

Monitoring the pest and disease development in crops can be time consuming and require specialist knowledge, especially with large farm areas. The fields and crops are rarely homogeneous, with ranging fertility and pest and disease pressures depending on the microclimate or presence of soil-borne pests and diseases. The monitoring of crops and the need to deal with problems at an early stage is critical to allow follow up treatments to be done in a timely manner, and prevent crop losses.

Satellite and drone based crop monitoring has become a tool allowing rapid assessment of large crop areas to identify crop stress and vegetation density, however the imaging technology currently foes not have the granularity to allow pest locations and pre-symptomatic detection to be done. Using ground based autonomous robotic platforms allowing a greater detail to be collected. The Slugbot project described by Campbell (2021) is an example of how the detection of two species of slugs in oilseed rape can be done to allow a follow treatment with a biological control treatment directly to the slug, all with autonomous robots.

Plant phenotyping has used spectral imaging and has now evolved with multispectral systems for early detection system for visually asymptomatic disease phases. Veys et al. (2019) describes the early detection of light leaf spot in oilseed rape using machine learning able to detect light leaf spot infection with 92% accuracy. The structure of the plant is recorded using photometric stereo, the leaf angle and surface texture to allow for any reflection to be taken into account.

2.4. Vegetation density and crop health

Normalized Difference Vegetation Index (NDVI) is commonly used by both ground based and satellite imagery and serves as an indicator of the health of plants. Such monitoring of fields identifies problems before symptoms are visible to match the crop inputs to the exact need as identified. This has been done with fertiliser variable dose application in particular. The NDVI index measures the difference between visible and near-infrared reflectance of the vegetation, taking into account leaf area and chlorophyll content. It is now often used with satellite imagery, making NDVI more accessible to farmers as it now uses high-resolution aerial photography.

2.5. Spray application technology

Spray application for arable crops is traditionally done with horizontal boom hydraulic sprayers using flat fan nozzles and cone nozzles for tree crops. Such nozzles have a time delay to produce the required spray angle, pattern and droplets. With variable rate application nozzles need to be able to be opened and closed at regular intervals without affecting the droplet size distribution. The development of pulse width modulation described by authors such as Ramón Salcedo et al. (2022) allows the control of flowrates of the nozzles on variable-rate air-assisted orchard sprayers. Pulse-width modulation (PWM) sprays have been shown to improve the flow accuracy (Longlong et al., 2022), which is done by controlling the relative proportion of opening time of the solenoid valve. The use of PWM allows low flow rates to be used in the field while maintaining the droplet distribution, critical for efficacy and drift control.

3. DISCUSSION/CONCLUSIONS

Precision farming is becoming increasingly urgent due to the ever increasing demands for food production and the need for sustainable systems which make efficient us of the crop inputs and have a low impact on the environment through contamination of natural resources. The need to move towards net zero carbon requires a more targeted approach to crop production with reduced synthetic inputs such as pesticides and fertilisers.

The technology now exists to gather real-time data in the field using a wide range of mobile and static sensors available through the Internet of Things (IOT) and rapid analysis of the data to give the farmer information in a timely manner. Monitoring with satellites and drones, are particularly useful for large areas of land, however statice sensors can be used in greenhouses.

Early detection of problems and crop stress through pest and disease pressure or environmental factors allows early intervention which is more costs effective. The increasing automation of data collection is matched by the development of robotic platforms to monitor the crop and apply appropriate inputs. The move away from synthetic pesticides towards biologicals requires a timely approach to intervention, before pests and disease pressures become too great.

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