Practice PF n° 17

LEVERAGING DRONE TECHNOLOGY FOR FERTILIZER OPTIMIZATION IN TOMATO AND CORN CROPS

Introduction

Category: Good Practice (GP)

Practice identity card

#Nutrient variability in fields, Crop-specific fertilization

#PF, Food, Feed, Fibre, Oil, Ornamental, Industrial, tomato crop, corn crop

Short description

- ➔ Fertilizer management using drones is an advanced precision agriculture technique that optimizes nutrient application, enhances yields, and reduces environmental impact. This practice integrates drones equipped with multispectral cameras, specialized software for data analysis, and precision farming machinery to ensure efficient fertilizer application. For example, a tomato farmer in Poland uses the DJI Mavic 3M drone equipped with a multispectral camera to monitor plant health and create Variable Rate Application (VRA) maps. The drone collects images of the field, capturing light in different spectrums, including near-infrared (NIR), to generate the Normalized Difference Vegetation Index (NDVI), which highlights variations in plant vigor and nutrient requirements.
- ➔ The process begins with the drone flying over the tomato field and capturing multispectral images at specific intervals. Using software such as DJI Terra or DJI SmartFarm, the collected data is processed into NDVI maps that identify areas of the field with varying nutrient needs. The NDVI data is then transferred to platforms like Pix4Dfields or QGIS, which generate detailed VRA maps. These maps divide the field into zones based on nutrient requirements, guiding fertilizer application. Farmers can also integrate additional data, such as soil analysis results, to refine the recommendations further. Once the maps are generated, they are exported as files compatible with fertilizer spreader systems such as Amazone Amatron, Kuhn CCI Terminal, or John Deere Operations Center. These files are transferred to the machinery using a USB or SD card, enabling the spreader to adjust fertilizer rates automatically during application. After the fertilization is complete, the drone conducts another flight to assess changes in plant health, confirming the effectiveness of the measures taken. This post-application monitoring allows farmers to evaluate the overall success of the fertilization strategy, using data collected before and after fertilization. By adopting this practice, the tomato farmer reduced fertilizer usage by 30%, saving costs while maintaining high yields. Targeted application minimized nutrient runoff, improving soil and water quality in the region. Additionally, the optimized strategy increased crop uniformity, resulting in better-quality tomatoes suitable for premium markets. The environmental benefits of this practice include reducing the reliance on heavy machinery, which prevents soil compaction and crop damage, and lowering greenhouse gas emissions by applying fertilizers only where needed. Drones can also access hard-to-reach areas, ensuring comprehensive field coverage and maximizing efficiency.

Implementation process

Which practice is considered as the standard in this region? The standard practice in this region involves collecting soil samples and conducting laboratory analyses to determine the nutrient content and fertility of the soil. This method provides farmers with general recommendations for fertilization based on the average nutrient needs of the crop and soil conditions across the entire field. While effective for understanding baseline soil fertility, this approach does not account for spatial variability within fields, which can lead to inefficiencies such as over-fertilization in some areas and under-fertilization in others.

What was the on-farm issue/challenge/opportunity that led to the implementation of the practice? The adoption of this practice addresses key inefficiencies in traditional fertilizer application, such as uniform dosing that leads to resource waste, reduced yields, and environmental harm. By leveraging data-driven tools like drones and GPS-enabled machinery, it ensures site-specific application, optimizing nutrient use and saving time for younger, tech-savvy farmers. Regulatory pressures, including compliance with eco-scheme fertilizer dose limits, and economic drivers like rising input costs further motivate adoption. This practice reduces nutrient leaching, minimizes greenhouse gas emissions, and supports sustainable and profitable farming.

How long did it take to implement the practice and which are the measures needed to monitor: The implementation of the practice typically takes around one year, which includes time for acquiring the necessary equipment, training farmers on using digital tools and machinery, and collecting baseline data such as soil and yield maps. Monitoring measures involve regular drone flights, analysis of NDVI and other vegetation indices, and periodic soil sampling to assess the effectiveness of fertilizer application and make adjustments as needed.

Logistics

- **Logistic aspects to consider:** Drone operators must undergo special training and pass a state exam depending on the type of drone. Possibility of using public aid under Agriculture 4.0 program
- **Other specific tools involved/included:** The practice involves the integration of various tools and equipment to ensure effective implementation. Key equipment includes the DJI Mavic 3M drone, equipped with a multispectral camera for vegetation condition analysis, and a fertilizer spreader with variable application rate capabilities (e.g., Amazone, Kuhn, or Kverneland models compatible with ISOBUS or application maps). If the spreader lacks built-in GPS, an external GPS/RTK device is required for precise location tracking. Additionally, a laptop or tablet is used for data processing and analysis.
- The software required includes DJI Terra or DJI SmartFarm for processing drone data and generating NDVI maps. For creating prescription maps, tools like Pix4Dfields or QGIS are used. Dedicated software from the spreader manufacturer (e.g., Amazone Amatron, Kuhn CCI Terminal, or John Deere Operations Center) is necessary for map compatibility. A USB or SD card is used to transfer application maps to the spreader.
- The process begins with data collection, where the drone captures an aerial map of the field. The data is then processed and analyzed using multispectral indices like NDVI to generate variable field maps. These maps are loaded onto the fertilizer spreader, which is configured for site-specific application. Finally, the fertilization is executed, and the results are monitored to assess

the effectiveness of the application, completing a precise and efficient cycle of fertilizer management.

- **Additional requirements for application:** The application of this practice requires GPS-enabled equipment such as drones with multispectral cameras (e.g., DJI Mavic 3M) for data collection and GPS-enabled tractors or fertilizer spreaders for precise nutrient application. If the spreader lacks built-in GPS, external GPS or RTK devices are needed for accuracy. Compatibility between GPS data, analysis software (e.g., Pix4Dfields, QGIS), and spreader systems (e.g., Amazone Amatron, Kuhn CCI Terminal) is essential, requiring support for formats like shapefiles or ISO- XML. Training is necessary to operate drones, process data, and configure equipment, with regular maintenance and calibration ensuring reliable performance.
- **Skill/education level required:** rather high

Agronomical traits

- **Can the practice be applied to a multitude of cultivation techniques?** This practice can be applied to various cultivation techniques, including row crops such as wheat, maize, and barley, as well as orchards, vineyards, and high-value vegetable crops like potatoes, carrots, and tomatoes. It is particularly effective in crops with high nutrient demands and variability, such as maize and wheat, where precise fertilization boosts yield and reduces costs. In orchards and vineyards, drones and sensors provide detailed insights for targeted management of individual trees or vines, while in vegetables, the practice enhances uniformity and reduces fertilizer overuse, ensuring high-quality production.
- **Targeted crop categories:** food, feed, fibre, oil, ornamental, industrial
- **Influence on soil quality:** Soil quality will be improved. Lower soil salinity, increase in organic matter, better soil moisture conditions.
- **Suitable soil types:** sandy, peaty, clay, loamy, chalky, silty
- **Expected effect on crop yield**: increase
- **Expected effect on crop yield variation**: decrease
- **Expected effect on crop quality:** increase
- **Expected effect on crop quality variation:** decrease
- **Which costs may increase due to the practice?** equipment, internet / data subscription costs, skilled labour
- **Which costs may decrease due to the practice?** unskilled labour, fertilizers, herbicides, pesticides, fuel, transportation, storage, energy
- **Expected long-term/indirect economic benefits of the practice:** It reduces fertilizer consumption by 1/3, supports rational management in accordance with the applied eco-schemes, reduces production costs and improves product quality.
- **Expected effect on the leaching of nutrients:** The practice reduces nutrient leaching by applying fertilizers precisely where needed. Nitrogen leaching is minimized by avoiding over-application, preventing groundwater contamination. Phosphate leaching is reduced as targeted application prevents runoff

Administrative context

- **Does the practice qualify for subsidies?** Yes. Agriculture 4.0 program.
- **Status of the legal framework that regulates the practice:** Existing, however with gaps
- **Are there any policy barriers complicating the practice’s application?** No
- **Does the practice involve the use of hazardous substances?** No
- **Is the practice supported by Eco-schemes?** No

- **Are there any gaseous emissions to be considered upon application of the practice?** No
- **Greenhouse gas (GHG) reduction potential of the practice:** little or none
- **Expected effects from the practice on the time occupation of the farmer?** time-saving
- **May the practice contribute to a better public image of agriculture?** Yes, this practice can significantly enhance the public image of agriculture by demonstrating a commitment to environmental stewardship, economic efficiency, and technological innovation. The optimization of fertilization reduces nutrient leaching and greenhouse gas emissions, showcasing agriculture as a proactive contributor to environmental protection. Lower production costs, achieved through efficient fertilizer use, can translate into more affordable products for consumers, fostering a positive perception of farming's role in addressing economic challenges. Additionally, the precise application of nutrients helps produce healthier, higher-quality crops, appealing to consumers increasingly concerned with food safety and sustainability. The integration of advanced technologies such as drones, GPS-enabled equipment, and data-driven software highlights the modernization of agriculture. This technological progress portrays farming as a forward-thinking, innovative industry that balances productivity with environmental responsibility. Collectively, these factors strengthen the relationship between farmers and consumers, positioning agriculture as a key player in creating a sustainable future.
- **May the practice improve the farmer's self-image?** Yes. Pride in skills operated with specialized equipment.

Contact

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