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THE PRECISION AGRICULTURE PARADIGM: OPTIMIZING INPUTS AS A SOLUTION FOR ECONOMIC PERFORMANCE

Tiberiu IANCU[1], Ioan BRAD[1], Claudia SÎRBULESCU[1], Camelia MĂNESCU[1],
Iuliana MERCE[1], Anka PASCARIU[1], Marius GORDANU[1], Mihaela IANCU[1], Dragoș CHENDE[2]

[1]*University of Life Sciences “King Mihai I” from Timisoara, Faculty of Management and Rural Tourism, Timisoara, Romania*
[2]*Doctoral School “Engineering of Vegetable and Animal Resources”, University of Life Sciences “King Mihai I” from Timisoara, Romania*

Abstract: In the context of increasing pressures on natural resources and the need to increase the competitiveness of the agricultural sector, precision agriculture is emerging as an innovative paradigm capable of optimizing the use of inputs and reducing environmental impact. The present study analyzes the role of precision agriculture technologies in improving the economic performance of agricultural holdings, while reducing pressure on resources and reducing negative externalities.

• Introduction

The increase in the costs of agricultural inputs, environmental pressures and market volatility require a reconfiguration of the way farms are managed. Precision Agriculture (PA) offers a technological framework for optimizing the use of resources (water, fertilizers, pesticides, energy), through data-driven decisions (sensors, satellite images, GPS, variable rates). The relevance of the topic derives from the need to increase economic efficiency while reducing environmental impact, in line with the CAP objectives and sustainability requirements. Theoretically, the Precision Agriculture paradigm shifts the focus from uniform inputs to spatially and temporally differentiated application, which allows for the correction of intra-plot heterogeneity. In practice, the adoption of PA technologies is uneven, being influenced by farm size, capital, digital skills and access to advisory services.

• Material and method

From a methodological point of view, the research uses a mixed approach. The quantitative component includes the analysis of data on the use of inputs (fertilizers, water, pesticides) and agricultural productivity, by applying econometric models to evaluate efficiency. In addition, comparative analysis techniques are used between conventional agricultural systems and those based on precision agriculture. An environmental impact assessment is also integrated using methods to quantify the effects on emissions and resource use.

• Results and discussions

The results highlight that precision agriculture significantly contributes to optimizing the use of inputs, reducing production costs and improving economic yields. At the same time, there is a decrease in environmental impact, by reducing resource consumption and associated emissions.

Table 1. Input Use Efficiency: Traditional vs. Precision Agriculture

Indicator	Traditional system	Precision agriculture
Fertilizer consumption (kg/ha)	180-220	130-170
Pesticide consumption (l/ha)	6-8	4-6
Water consumption (m3/ha)	3,500–4,500	2,500–3,200
Input cost (€/ha)	600–750	450–600
Average yield (t/ha)	4.5–5.5	5.5–6.5

Precision farming reduces inputs by ~15–30% and increases yields by ~15–20%. The net effect is higher factor productivity and lower unit cost.

Although costs increase over time (input inflation), precision farming cushions growth and accelerates yields, increasing margins. Precision farming doubles profit/ha in typical scenarios and achieves an ROI of 2–4 years, depending on farm size and technology mix.

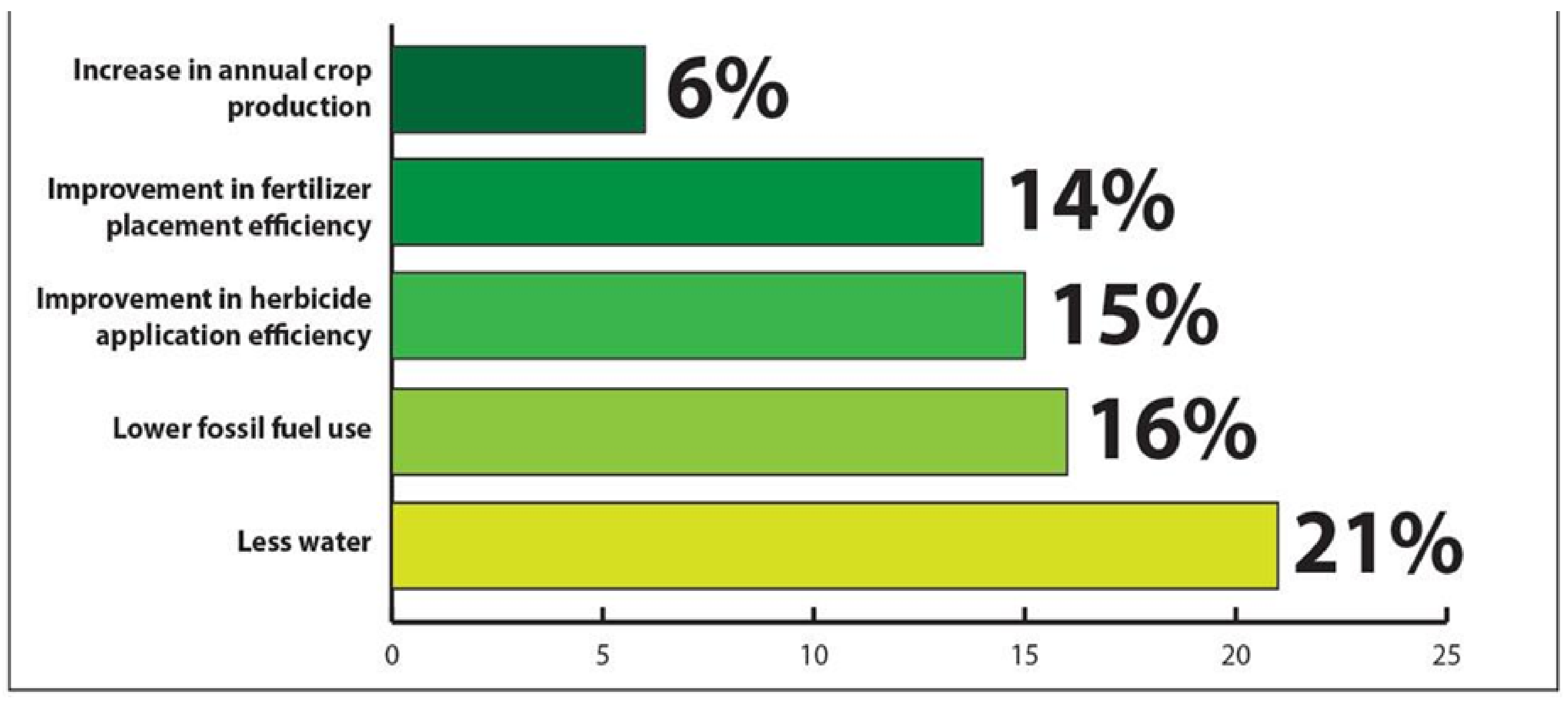

Figure 1. Benefits of increased adoption of precision technology

This type of agriculture also has beneficial effects on the environment, reducing inputs leads to a decrease in the carbon footprint and an improvement in environmental indicators.

• Conclusions

Precision agriculture confirms a substantial improvement in economic performance by optimizing inputs and increasing yields, along with environmental benefits. The effects are robust across scenarios, but depend on technological calibration and agronomic management.

The conclusions emphasize the importance of the wide-scale adoption of precision agriculture technologies, as well as the need to develop supporting policies and instruments to facilitate the transition to efficient and sustainable agricultural systems.

To maximize impact, the following are necessary:

- ❑support schemes(subsidies, green credits) to reduce the initial cost;
- ❑development of digital skillsand consulting services;
- ❑data infrastructure(imaging, local weather stations);
- ❑cooperation models(shared services) for small farms.

In conclusion, the PA paradigm represents a scalable solution for competitiveness and sustainability, with direct effects on the profitability and resilience of the agricultural sector.