# Impacts of Conservation and Precision agriculture management practices on energy use and carbon footprint of winter cereals

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## Extended abstract

Conservation agriculture and precision agriculture are two major components for the broader concept of Regenerative Agriculture that aims on rehabilitation of soil and ecosystem's function, eliminating the dependance and the risks for pollution aroused from the use of chemical inputs, and assisting on the mitigation and adaptation to the climate change. Conservation agriculture has been a long term, widely acknowledged agronomic practice for preserving the physical and biological nature of the soils. Precision agriculture is a contemporary technique capitalizing on novel sensors, information systems and automation for managing natural field variability with regards of optimizing the efficiency of farm inputs. Despite the broad research upon the impacts of the two sustainable farming approaches their synergistic co-benefits are not clearly defined.

The current study presents preliminary findings from the first year of the project "PreConAgri", which is an operational group funded by the Greek Ministry of Rural Development and Food under Measure 16. The project aims at demonstrating the co-benefits of Conservation and Precision Agriculture techniques applied in winter wheat production on soil quality, crop productivity and climate change mitigation. To that end, an energy use and greenhouse gasses (GHGs) emissions analysis was performed over data collected from four pilot fields in two Greek regions with severe erosion problems, Kozani and Larissa. Two pilot fields were established in each region, and each pilot consisted of four plots with alternative management regimes: Conservation agriculture (CA), Precision agriculture (PA), Conservation and Precision agriculture (CPA) and Control (C).

Conservation agriculture included no-till planting, permanent soil cover and crop rotations. These are the three basic principles for Conservation Agriculture as defined by FAO [1]. Sowing on no-till in the CA and CPA treatments were performed with the help of two direct drilling machines, a Kuhn SDLiner 3000 that was used at the two fields of Larisa and a Gaspardo Diretta that was used for the Kozani pilots. The C and PA treatments were sown with the traditional farmer's sowing machines. The traditional farmer practices involved various tillage operations with deep tillage tools like moldboard ploughs, chisel ploughs or subsoilers and multiple passes of shallower tools like disk harrows, field cultivators, tooth harrows and roller packers in various combinations.

Precision agriculture included the techniques of variable rate fertilization (VRF) and controlled traffic farming (CFT). VRF concerned the superficial spring nitrogen applications but not the basal fertilization performed during sowing. In Kozani, the VRF was performed with the help of a commercial variable rate device (Augmenta Field Analyzer, Raven Industries Inc.). The device uses a video multispectral sensor and AI technology to record a company defined vegetation index called "Augmenta index". The index is sensitive to green vegetation while the AI component is used to discriminate plants from the ground. The application was successful only in one of the fields, because it was the first usage of the system, and its functions weren't yet well-conceived. In Larissa, VRF was performed also only in one field, semi-automatically with the help of prescription maps uploaded on a tractor GPS guidance device. The prescription maps were obtained from the One Soil platform [https://onesoil.ai/en] using the latest available NDVI information. The NDVI maps were classified into three classes: low 0-25% quantile, middle 0.25-0.75 quantile and high 0.75-1 quantile. At the middle class it was applied the regular, farmer defined, fertilizer quantity while in the low and high class the fertilizer dose was reduced by 25%. The dose regulation was achieved manually by altering appropriately the travel speed when entering a different class area that was visionally identified on the GPS guidance uploaded map. CFT involves optimum route planning by estimating the shortest route and designing a mission plan that will be implemented with the help of GPS guidance device. This task is regarded to be performed by IBO using a smart, route optimization algorithm and will start from the second year of the research.

Energy use and carbon flows were estimated with the Cool Farm Tool (v2.11.0) [https://coolfarm.org/]. The tool provides scientifically robust assessments for greenhouse gasses cycles, water footprint, biodiversity, food loss and waste for open farming and livestock. In the present study, the greenhouses pathway was followed. A detailed registry of all the farm inputs regarding the crop, the field tasks, fertilizers and crop protection products, irrigation, residue management etc were inserted into the tool, for each farm. Apart from that, information about the land use and the soil characteristics was also necessary. The data were obtained from soil sampling and soil analysis during the first year for defining the baseline conditions. Yield data were obtained by harvesting separately each plot and weighting the grain production. The system's boundary was defined at the field gate, so transportation was excluded from the inventory. The outputs of the analysis provide information about $CO_2$, $N_2O$ and $CH_4$ emissions, all expressed as $CO_2$ equivalents ($CO_2$eq) per ha and per tonne of product as well as information about the diesel and electricity consumption and the energy usage.

The first-year results showed that conservation agriculture provided a considerable energy saving from diesel usage. Compared to the traditional farmer practices, CA reduced the energy usage from the range of 2230 - 3150 MJ/ha to 1430 - 1720 MJ/ha, a reduction of 35.9 to 49.7%. Precision agriculture with VRF on the other hand was capable of reducing the nitrogen usage during the spring applications from 4.8 to 8.8%. The savings on energy and nitrogen resulted in a respective reduction of GHGs emissions. In addition, CA provided soil carbon stock changes of 57 to 133 kg $CO_2$eq per ha resulting on a total GHGs mitigation of 97.3 to 109.1% higher compared to the control while precise fertilizer application prevented soil $N_2O$ losses by 3.2 to 5.9%.

Crop yield in CA was -4.5% lower to 1.3% higher compared to the control. PA affected the yield from -1.6% to 3.1%. The CPA treatment that combined conservation and precision agriculture practices resulted in yield changes from -4.9 to 0.9%. Expressing the GHGs changes per tonne of product it was estimated that CA provided $CO_2$eq savings of 12.6-27%, the PA savings of 1-5.5% and the CPA combination savings of 14.3-29.5%.

The above results highlight the importance of conservation agriculture as a core element practice for mitigating GHGs emissions into a regenerative farming approach. Variable rate fertilization proved also a valuable practice for reducing GHGs but also, eliminating the risks for groundwater pollution, a thread that wasn't evaluated in this study. Another impact that this study wasn't able to evaluate during the first year was the energy savings from controlled traffic farming because it will start on the second one. Overall, the combination of conservation and precision agriculture practices provided the best results with synergistic co-benefits on soil GHGs emissions.

*Keywords: Conservation agriculture, precision agriculture, energy use efficiency, greenhouse gas emissions*

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