Sustainable agriculture in Carbon arithmetics: LIFE+ Agricarbon

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Keywords: conservation agriculture, precision agriculture, climate change, Agricarbon

Introduction

Conservation Agriculture (CA) is based on a total or partial reduction of in-field ploughing tasks, keeping a protective plant cover on the soil; using Precision Agriculture (PA), there is a more efficient use of inputs by reducing the overlaps between the different machine passes and site-specific input application. The synergies produced by their joint use, constitute a set of sustainable agricultural techniques which, through energy-saving and the sink effect of atmospheric carbon, contribute to a notable reduction in atmospheric greenhouse gas (GHG) concentrations. Promoting their dissemination and demonstration will significantly aid the EU to fulfill its objectives to reduce GHGs and increase energy efficiency, both by 20%, by the year 2020.

The benefits of CA in relation to stopping erosion, fighting against desertification and improving air and water quality, have been widely demonstrated in many research efforts. The advantages of CA and PA techniques for climate change mitigation and energy saving and efficiency have been also the theme of many investigations made in the EU and elsewhere in the world. Some related to climate change are in Spain (Ordóñez et al., 2007) and (Álvaro-Fuentes and Paustian, 2011), and in the U.S.A. (Reicosky et al., 1997; Lal et al., 2007). Some have linked reduction of CO_2 emissions to the increase in the organic matter content produced in soils under CA cultivation (Tebrügge, 2003). The energy savings achieved both in CA and PA, mainly derived from an efficient use of machinery and reduction in inputs, especially fuel and fertilizers, due to the drastic reduction in work time for crop establishment and management, added to the effects from the reduction in atmospheric carbon emissions and sink mentioned above, make these agronomic practices a very useful tool in the fight against climate change in the agricultural sphere, which contribute 10% of the GHGs in Europe.

The European Union co-funded LIFE+ Agricarbon project aims to encourage the progressive establishment of sustainable agricultural techniques, CA and PA, contributing to GHG emission decreases and the adaptation of the agricultural system to the new climate conditions found in global warming. Also, making available to European and National authorities sufficient knowledge about these practices could serve to initiate environment policies in the agricultural domain, with the two-fold emissions reducing and adapting intention indicated in the European Commission Communications COM (2007) 2 final ´Limiting Global Climate Change to 2 degree Celsious- The way ahead for 2020 and beyond' and COM(2007) 354 final, Green Paper 'Adapting to climate change in Europe-options for EU action' and in Article 3.4 of the Kyoto Protocol on changes in agricultural soil uses.

Material and Methods

The LIFE+ Agricarbon project establishes a series of objectives based on a logical knowledge sequence: demonstration in field and evaluation of the techniques' benefits appearing in the bibliography through the initiation, compilation of the information generated and its subsequent dissemination.

The south of Spain (Andalusia), where is the study area, corresponds to a xeric moisture regime, according to standards established by the Soil Taxonomy. The climate has two opposite periods: one cold and wet during the fall and winter, and another warm and dry during spring and summer. The temperature regime is termic and the precipitations are very variable during the year and between years. All this, normally cause in the latter an important water deficit for crops.

The project is based on the establishment of a network of three pilot farms, working 90 hectares of herbaceous crops under two soil management systems (conventional tillage vs. CA supported by PA). Trials, in each management system, have a typical crop rotation of the Andalusian countryside: winter wheat, sunflower and legume. The crops sowed in the experimental fields were: Durum wheat (*Triticum durum*) and Sunflower (*Helianthus annuus*) in the 3 farms and chickpea (*Cicer arietinum*) in farm 1 and 3, and bean (*Vicia faba*) in farm 2.

Agronomically, farms are conducted according to the landowners' guidelines. We control remotely several parameters of the diverse operations accomplished. The indicators followed in every operation are: time spent; area worked; average speed; work capacity; overlap; fuel consumption and position of the tractor rear hitch. Tractors used are two John Deeres (models 6920 and 6110) and a New Holland TM120 (one for each farm). All tractors were equipped with the following common technology: a GPS model GM-48 UB Sanav; a fuel flowmeter model AIC-4008 Veritas y and a potentiometer model JX-PA-30-N14-21S Unimeasure. Furthermore, for the treatments under PA the tractor were equipped with a light bar model AgGPS EZ-Guide 500 Trimble. A data logger (DataTaker 85) is used as data acquiring system. The storage information about the operation is transmitted via modem to a PC with proper software. The crop production was handled with a monitor crop yield, Ceres 8000i RDS. The yield maps were obtained using the program Farm Works version 2010.1.433. Thanks to Google Maps and an own developed Basic language programmed software named "Reporter Life", we mark initial and end points of each individual operation for accurately determine the energy associated of field work.

Results and Discussion

In this paper we present partial results of mechanized operations and yields, related to the season 2009/10 (see Table 1 and 2). Due to the use of CA instead of conventional tillage, farmers have reduced their CO_2 emissions to the atmosphere avoiding ploughs. The use of CA and PA has reduced machine overlaps in seeding from over 11% to less than 6% in the case of CA supported by PA. First field results show that CA together with PA may significantly reduce the CO_2 emissions, as does not need the mouldboard plow, neither chissel plow, neither disc harrow, neither cultivator for establishing correctly the crop.

The precipitations registrated during the campaign 2009-10 wery extremely large, see figure 1. The rainfalls measured in field 1 were 1 061 mm, 913mm for 2 and 773 mm for 3, well above the average for the region, which is 470 mm. The large winter precipitation made that the growth of the winter crops, wheat and bean, were not appropiate, having a production under the average of the region in most of the situations, see table 2. However, the production of the spring crops, sunflower and chickpea, were near the average, except in field 1 where the legume suffered many deseases and it could not be harvested.

At the end of the project it is expected to have a better adaptation to climate change of majority crops in Mediterranean climate areas implemented under CA with support from PA, due to a greater efficiency in the use of measurable water in the increase in moisture content in the first 50 cm of the soil profile. Also a managed digital platform for the evaluation of GHG emissions and energy consumption on farms will be set up in www.agricarbon.eu website, including a protocol of energy and GHG monitoring on farms. Thanks to the practising of CA a fixation of between 0.60-1.50 metric tons more of CO_2 per hectare and year on farms with sustainable agricultural techniques with respect to those with conventional ones. Moreover a reduction of at least 20% of CO_2 emissions has been achieved associated due to the reduction in energy consumption with CA compared to conventional techniques. From the policy point of view we expect the project to favour measures supporting the implementation of CA and PA techniques and the inclusion of surfaces under them in the Spanish Survey of Surfaces and Crop Yields (ESYRCE) and the increase in CA surface measurable via indicators such as a specific machinery census, Geographic Information Systems, and ESYRCE data. Finally, a set of technical, practical and scientific documentation on the influence of CA and PA on atmospheric GHG concentration reduction will be available at the end of the LIFE+Agricarbon project.

Acknowledgements

The authors would like to thank the European Union's Financial Instrument LIFE for co-financing the LIFE+ Agricarbon project.

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Figures and Tables

Figure 1. Evolution of precipitation and temperature in experimental fields. Season 2009/2010.

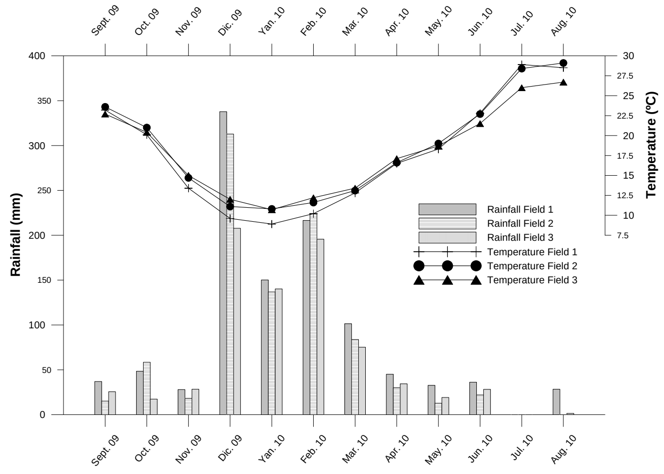

Table 1. Equipment used in the different fields of the project and its related CO_2 emissions. Season 2009/2010.

Equipment	Width (m)	Average Speed (km/h)	Fuel consumption (l/ha)	Work capacity (ha/h)	Overlaps (%)	Total emissions $kgCO_2/ha$	Emissions in overlaps $kgCO_2/ha$
Mouldboard plow	1	4.17	16.65	0.83	14.00	37.17	5.20
Chisel plow	2.75	5.08	16.48	1.09	16.10	39.99	6.44
Disc harrow	4	8.86	7.16	2.43	20.46	19.18	3.92
Cultivator 1	4	11.20	4.59	4.02	20.00	13.16	2.63
Cultivator 2	3.37	5.23	2.57	3.49	20.01	4.94	0.99
Fertilizer	15	8.68	1.47	8.88	33.30	3.82	1.27
No Till seeder with PA	3.23	8.32	7.06	2.26	5.45	17.55	0.96
Conventional seeder	3.6	11.10	3.60	3.88	11.37	10.03	1.14

Table 2. Crop Production (kg/ha) in experimental fields. Season 2009/2010.

	Field 1		Field 2		Field 3	
	NT	CT	NT	CT	NT	CT
Wheat	727	680	2 620	2 972	1 037	1 024
Sunflower	1 345	1 512	1 312	1 140	1 332	1 292
Legume	-	-	492	1 282	2 058	1 446