Extension of Irrigation in Semi-arid Regions: What Challenges for Soil Security? Perspectives from a Regional-Scale Project: Life Regadiox

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Abstract: The challenge of transforming agriculture to feed a growing population without harming natural resource such as soil requires a transition towards more productive agricultural production systems, with a more efficient use of inputs and more stability and greater resilience to risks, crises and climate variability in the long term. The conversion from dryland to irrigation in arid and semi-arid land is a widespread strategy in this sense. It can however significantly affect soil security, as it interferes with its four dimensions: capability, condition, capital and connectivity. The project LIFE REGADIOX aims to design, show, test, and spread the impact that an improved model of sustainable management of irrigated agriculture can have in climate change at a regional scale in Navarre (NE Spain). It addresses, among others, soil security and soil quality issues, including the effects of land management on climate regulation and the capacity of the soil to provide basic environmental services. A guide for good practices in irrigated land, which takes into account the particularities of local soil and cropping systems, has been developed based on from soil quality observations, GHG balances, and the evaluation of fertilization and irrigation techniques.

Soil Security has been defined as being concerned with the maintenance and improvement of the world's soil resource to produce food, fiber and freshwater, contribute to energy and climate sustainability, and maintain the biodiversity and the overall protection of the ecosystem[1]. As a multi-dimensional concept, it is related to the global existential environmental challenges: food, water and energy security, climate change abatement, biodiversity protection, and the maintenance of ecosystem services[2]. In many arid and semi-arid areas, significant amounts of agricultural land are being converted from dryland to irrigation, as a strategy to ensure stable productivity and/or high added-value agricultural goods, including fibers or energy crops. This change can significantly affect soil security, as it interferes with its four dimensions: capability (the productivity and production drastically change), condition (soils change as their inherent and dynamic properties can be affected by irrigation and intensive management), capital (the stocks can also increase as a result of increased productivity, such as soil organic C, or decline, for instance if erosion increases), and connectivity (decision taking is transferred from farmers to irrigation management bodies).

The project LIFE REGADIOX (*Stabilization of atmospheric CO_2 and greenhouse effect reduction through a sustainable management of irrigated agriculture*) aims to design, show, test, and spread the impact that an improved model of sustainable management of irrigated agriculture can have in the climate change. It has been developed in Navarre (NE Spain), where irrigation is rapidly increasing: more than 22,300 ha of rainfed agricultural land converted to irrigation in the last years, adding to the previous existing irrigated area of 70,000 ha. The project has three major axis related to soil security: (i) the study of net GHG balances in irrigated soils after the transformation from dryland, and in different management strategies under irrigation, (ii) the study of the potential of different irrigation strategies for optimizing energy and water consumption, and (iii) the study of the efficiency of different options for fertilization, including the use of several organic amendments. A fourth axis was included: the study of soil quality indicators (physical, chemical and biological soil properties used to

evaluate soil functions at different levels), to better understand the consequences of the extension of irrigation on soil functioning.

The study was conducted on a series of agricultural plots selected considering the particularities of climate and soils in the region, in three irrigation districts (Valtierra, Miranda de Arga and Funes). This allowed for the creation of a network of representative plots. On this network, a detailed soil study was conducted for three years (2013-2016), including the determination of accurate soil organic C stocks, soil quality indicators and the estimation of GHG balances associated to the most widespread cropping systems in irrigated land, and in comparison to baseline dryland systems. In particular, irrigated cereals (maize), fodder production, intensive horticultural rotations and permanent woody crops (vines and olive trees) were monitored. Dryland references include rainfed (wheat and barley) cereals.

The results of this project have shed light on several soil security issues in the region. In particular, they have allowed for identifying the differences in soil quality and GHG balances in the studied agrosystems. A synthetic expression of these results is summarized in Table 1.

Table 1: Qualitative evaluation of soil quality (SQ) parameters and soil C sequestration in three irrigation districts in Navarre (NE Spain).

Irrigation district			Valtierra			Miranda De Arga			Funes	
		Prof. (cm)	Dryland	Organic dryland	Annual irrigated	Dryland	Annual irrigated	Irrigated fodder	Dryland	Annual irrigated
Physical SQ	BD	0-15		=	=		=	=		=
		15-30		=	=		=	=		=
	SWHC	0-30		=	-		+	+		=
Biological SQ	MBC	0-15		=	=		=	=		=
		15-30		+	=		-	-		=
	AWCD	0-15		=	=		+	+		+
		15-30		=	+		=	=		+
	NSU	0-15		=	+		=	=		+
		15-30		=	+		-	=		+
Organic matter	C-POM	0-30		+	+		=	=		+
	SOC	0-30		+	+		+	+		+

BD: Bulk density; SWHC: Soil water-holding capacity; MBC: Microbial biomass C; AWCD: Average well-color development in BioLog EcoPlates®; NSU: Number of substrates used in BioLog EcoPlates®; C-POM: C in particulate organic matter; SOC: Soil C storage. Cells marked in the table "+" in green had positive differences with the control (dryland), "=" in grey, no differences and "-" in red, negative differences (P<0.05).

As a result of this project, and arising from soil quality observations, GHG balances, and the evaluation of fertilization and irrigation systems assessment, a guide for good practices in irrigated land, which takes into account the particularities of local soil and cropping systems, has been developed. It should be incorporated to extension advice and regional agricultural policies in the near future.

References

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