

Sustainable P management in Spanish agricultural irrigated systems



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INTRODUCTION

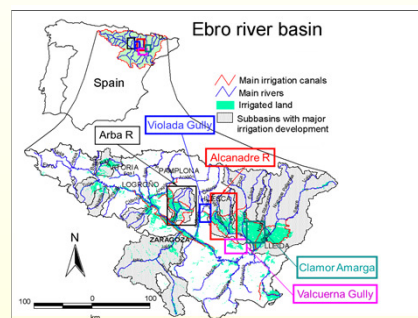
In semi-arid irrigation areas, one of the most important surface water quality problems is nutrient pollution from agriculture through irrigation return flows, which can lead to their eutrophication. The Ebro Basin Authority (Spain) and the Alto Aragon Irrigation District has supported several monitoring programs to control the water quality of irrigation return flows, including: (1) Determination of the phosphorus concentrations and loads in different agriculture areas (Skhiri and Dechmi, 2011); (2) Quantification of the phosphorus mass balance (Skhiri and Dechmi, 2012) and (3) Evaluation of the P fertilization practices and identification P risk areas (Dechmi et al., 2013; Dechmi and Skhiri, 2012).

P monitoring program at large scale

Total monitored area = 194120 ha (24% of irrigated area in the Ebro Basin)

Table 1. Hydrological years (HY), the non-irrigation season (NIS) and the irrigation season (IS) total phosphorus mean concentration values (mg L⁻¹) measured from 2010 to 2013.

Watershed	2010			2011			2012			2013		
	NIS	IS	HY	NIS	IS	HY	NIS	IS	HY	NIS	IS	HY
Violada	0.06	0.09	0.08	0.06	0.11	0.09	0.08	0.10	0.09	0.03	0.03	0.03
Alcanadre	0.10	0.23	0.18	0.09	0.15	0.12	0.06	0.09	0.08	0.07	0.14	0.11
Clamor Amarga	0.69	0.64	0.66	0.60	0.46	0.53	0.66	0.45	0.56	0.49	0.66	0.57
Valcuerna	0.19	0.19	0.19	0.06	0.56	0.32	0.06	0.13	0.10	0.03	0.04	0.04

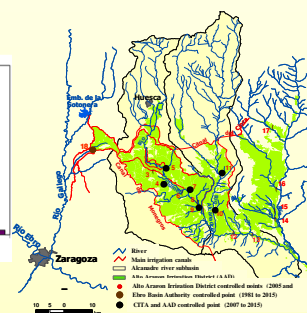
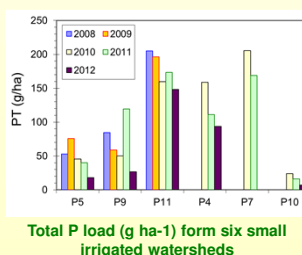


P monitoring program at small scale

Total monitored area = 24998 ha

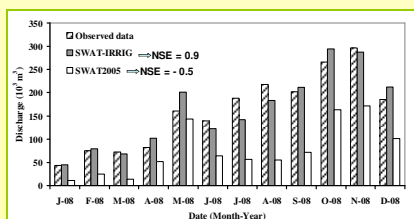
Table 2. Hydrological years (HY), the non-irrigation season (NIS) and the irrigation season (IS) total phosphorus mean concentration values (mg L⁻¹) measured from 2010 to 2012.

Watershed	2010			2011			2012		
	NIS	IS	HY	NIS	IS	HY	NIS	IS	HY
P4(LA Sardeta)	0.10	0.12	0.11	0.10	0.13	0.09	0.06	0.13	0.09
P5 (C-6)	0.06	0.05	0.03	0.02	0.05	0.04	0.04	0.04	0.03
P7 (Del Común)	0.05	0.06	0.05	0.06	0.07	0.07	0.06	0.02	0.04
P9 (Las Filadas)	0.01	0.02	0.02	0.05	0.02	0.04	0.01	0.02	0.01
P10 (Malfarás)	0.02	0.01	0.01	0.02	0.02	0.02	0.01	0.01	0.01
P11 (Del Reguero)	0.06	0.12	0.09	0.09	0.13	0.12	0.09	0.14	0.12



Best management practices using SWAT-IRRIG model

SWAT-IRRIG = adapted SWAT model to intensive irrigated watersheds.

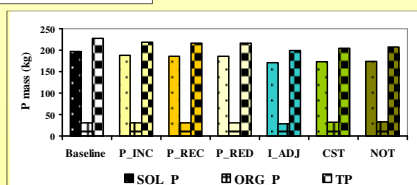


Comparison of monthly discharge between observed data and simulated using SWAT2005 and SWAT-IRRIG.



Del Reguero watershed characteristics

Surface: 1,865 ha (71% irrigated)
 Climate: semiarid
 Average Precipitation: 391 mm
 Average ET₀: 1294 mm
 Irrigation systems: solid-set sprinkler (96%)



Baseline vs. individual BMPs

BMP scenarios	
Nutrient management	1. P_INC: Phosphorus fertilizer incorporation
	2. P_REC: Recommended P fertilizer dose
	3. P_RED: Reduced phosphorus fertilizer dose
Irrigation management	4. L_ADJ: Adjusted irrigation dose
Tillage operations	5. CST: Conservation tillage
	6. NOT: No tillage
Combined BMPs	7. L_ADJ + CST
	8. L_ADJ + NOT
	9. L_ADJ + P_INC
	10. L_ADJ + P_REC
	11. L_ADJ + P_RED
	12. P_REC + P_INC
	13. P_REC + CST
	14. P_REC + NOT
	15. P_RED + CST
	16. P_RED + NOT
	17. L_ADJ + CST + P_REC
	18. L_ADJ + NOT + P_REC
	19. L_ADJ + CST + P_RED
	20. L_ADJ + NOT + P_RED

Table 3. Initial conditions and the percentage changes resulted from each BMP application of organic phosphorus (ORG_P, kg), soluble phosphorus (SOL_P, kg), and total phosphorus (TP, kg) average values; and average calculated gross margin (€ ha⁻¹) and the changes (€ ha⁻¹) from the initial condition scenario for corn, alfalfa and barley.

Scenario	ORG_P	SOL_P	TP	Corn (€ ha ⁻¹)	Alfalfa (€ ha ⁻¹)	Barley (€ ha ⁻¹)
Initial conditions (kg)	30.6	197.0	227.6	631.1	970.7	421.1
Percentage changes from initial conditions (%)						
1. P_INC	-0.1	-4.7	-4.0	-15.5	-15.5	-15.5
2. P_REC	-0.1	-5.8	-5.0	148.0	12.8	84.6
3. P_RED	-0.1	-5.9	-5.1	274.9	141.0	141.0
4. L_ADJ	-6.7	-13.7	-12.8	-11.9	-76.0	112.4
5. CST	+5.3	-12.4	-10.0	33.7	47.5	53.8
6. NOT	+9.1	-11.9	-9.1	14.6	38.8	49.8
7. L_ADJ + CST	-5.9	-24.9	-22.3	21.7	-28.5	166.2
8. L_ADJ + NOT	-3.0	-24.6	-21.7	2.6	-37.2	162.2
9. L_ADJ + P_INC	-6.7	-14.1	-13.1	-27.4	-91.5	96.9
10. L_ADJ + P_REC	-6.7	-13.6	-12.6	136.1	-63.2	197.0
11. L_ADJ + P_RED	-6.8	-19.7	-17.9	263.0	64.9	253.3
12. P_REC + P_INC	-0.1	-5.9	-5.1	132.5	-2.7	69.1
13. P_REC + CST	+5.3	-12.7	-10.3	181.7	60.3	138.4
14. P_REC + NOT	+9.1	-12.1	-9.2	162.6	51.6	134.4
15. P_RED + CST	+5.3	-12.7	-10.3	308.6	188.5	194.8
16. P_RED + NOT	+9.1	-12.1	-9.2	289.5	179.8	190.8
17. L_ADJ + CST + P_REC	-5.8	-24.9	-22.3	169.7	-15.7	250.8
18. L_ADJ + NOT + P_REC	-3.0	-24.7	-21.7	150.6	-24.5	246.8
19. L_ADJ + CST + P_RED	-5.9	-25.2	-22.6	296.6	112.4	307.2
20. L_ADJ + NOT + P_RED	-3.0	-24.8	-21.9	277.5	103.7	303.2

* α = 0.05; § α = 0.10

- Four large irrigated watersheds monitored (194120 ha): the annual total P mean concentration ranged between 0.03 mg L⁻¹ and 0.66 mg L⁻¹.
- Six small irrigated watersheds monitored (24998 ha): the annual total P mean concentration ranged between 0.01 mg L⁻¹ and 0.14 mg L⁻¹.
- The BMPs only targeting the source factor (P_INC, P_REC and P_RED) resulted in low percent reduction of TP (-4.7% on average, compared to initial conditions).
- The optimum irrigation management (L_ADJ) according to crop net irrigation requirement, was the most appropriate BMP as it decreased significantly the WYLD, TSS, ORG_P, SOL_P, and TP losses.
- The most relevant conclusions are related to the use of several BMPs combined.
- The combination of adjusted irrigation dose, reduced P fertilizer dose and conservation tillage BMPs (L_ADJ+P_RED+CST) led to the highest percent reduction of TP losses for DRW (-22.6%).
- For corn and alfalfa, the highest increase in gross margin was reached by the combination of reduced P fertilizer dose and conservation tillage BMPs (P_RED+CST): 308.6 and 188.5 € ha⁻¹, for respectively corn and alfalfa.

SUMMARY