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DSSAT MODELLING FOR BEST IRRIGATION MANAGEMENT PRACTICES ASSESSMENT UNDER MEDITERRANEAN CONDITIONS

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Introduction and objective

Sustainable water management in agriculture aims to match water availability and water needs in terms of quantity and quality and in space and time with acceptable environmental impact, especially in arid and semi-arid regions, where irrigation is required to reach a competitive and profitable agriculture. The objectives of this research were to (1) calibrate and validate the DSSAT model for the main crops of a modernized irrigation district located in the Ebro Valley (Spain) after irrigation performance characterization at the farm-field scale and (2) determine the best management irrigation practices under different soil types and crop requirements.

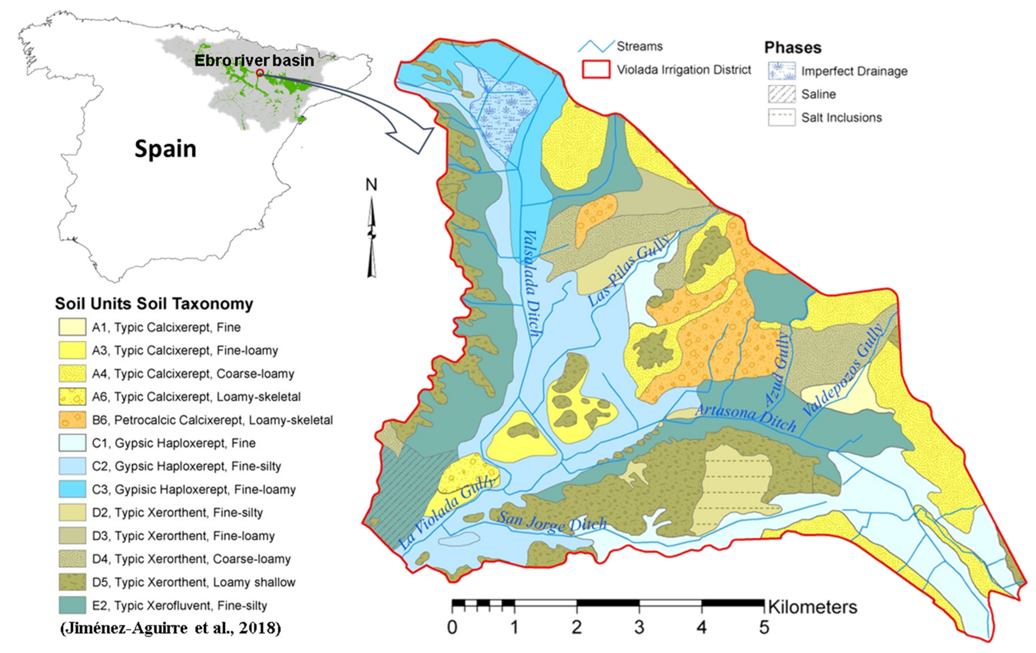

Figure 1. La Violada Irrigation District (VID) localization and soils types.

Materials and Methods

- The field experiments were performed during the 2015 and 2016 crop seasons in 54 farmer's fields of the VID (Fig. 1). Measured data from the 54 plots were used for DSSAT model calibration and evaluation of the main crops (barley, wheat, maize long season (maize-LS) and maize short season (maize-SS) and sunflower). In the case of alfalfa, the field experiment described by Malik et al. (2018) was used.
- The field crops selection was conducted in order to represent the dominant soil types (8 soil types) in the study area for each crop.
- Two irrigation scenarios were evaluated in the eight soil types for both seasons (the current irrigation practices and the irrigation dose adjusted to crop requirement and soil properties).

Results and Discussion

Both DSSAT calibration and validation demonstrated a good performance for all crops (Table 1).This study indicate that farmers' practices do not match well with irrigation schedule and depth (Table 2). The same irrigation scheduling was observed for the different soils. Yield losses due to drought stress were identified for wheat, barley and alfalfa and excessive irrigation water depth was applied for maize-LS, maize-SS and sunflower. The optimal irrigation schedule could improve the water use efficiency by 22.5%, 22.0%, 86.0%, 35.0% and 26.0% for maize-SS, maize-LS, sunflower, barley and alfalfa, respectively. Also could reduce the amount of leached N and deep percolation losses by 31% (4.48 T) and 34% (1.2 hm³), respectively (Fig. 2).

Table 1. Model calibration and validation performance.

		Grain Yield				Vegetative biomass			
		R^2	d-stat	BIAS	RMSE	R^2	d-stat	BIAS	RMSE
Maize_SS	Calibration	0.90	0.97	460	607	0.42	0.96	-385	1934
	Validation	0.98	0.98	-448	622	0.78	0.94	183	2895
Maize_LS	Calibration	0.99	0.78	-259	694	0.26	-0.65	808	1434
	Validation	0.90	0.88	-277	679	0.21	0.73	2392	2522
Sunflower	Calibration	0.97	0.91	424	565	0.73	0.75	521	733
	Validation	0.98	0.91	-282	463	0.55	0.71	380	603
Barley	Calibration	0.88	0.88	379	497	0.85	0.92	167	478
	Validation	0.97	0.99	75	478	0.82	0.91	-443	934
Wheat	Calibration	1.00	1.00	-102	317	1.00	0.72	2087	2231
	Validation	0.99	0.98	302	587	0.51	0.95	-1570	3635

Table 2. Comparison between current (CI) and optimal (OI) scenarios of grain yield, irrigation doses, irrigation application, deep percolation losses, leached N and residual soil mineral N for shallow and/or low permeability soils and high permeability soils.

		Grain yield (kg ha^{-1})		# Irrigation events		Irrigation depth (mm)		Leached N (kg N ha^{-1})		Deep percolation (mm)		N soil (kg N ha^{-1})	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Maize-SS													
Shallow / high permeability soils (B6, A4, D4)	**CI**	11037	10014	96	125	657	780	203	148	191	50	60	166
	OI	11037	11623	73	75	507	553	111	154	21	55	182	118
Low permeability soils (E2, C1, C2, C3, D5)	**CI**	11240	11593	96	125	653	780	57	15	25	2	104	127
	OI	11156	11652	76	72	515	523	5	15	1	2	150	117
Maize-LS													
Shallow /high permeability soils (B6, A4, D4)	**CI**	12584	12106	95	110	766	732	108	17	176	123	71	152
	OI	12584	12260	70	92	526	697	12	17	111	123	154	146
Low permeability soils (E2, C1, C2, C3, D5)	**CI**	12784	12250	95	110	766	732	9	1	24	7	112	114
	OI	12631	12303	77	92	569	685	0	1	5	7	128	114
Sunflower													
Shallow / high permeability soils (B6, A4, D4)	**CI**	4148	2804	60	68	492	456	90	33	192	69	4	40
	OI	4110	4207	34	59	229	466	36	33	69	69	3	5
Low permeability soils (E2, C1, C2, C3, D5)	**CI**	4137	2326	60	69	486	458	9	0	45	0	4	67
	OI	4037	4283	51	72	380	562	0	0	0	0	5	10
Barley													
Shallow / high permeability soils (B6, A4, D4)	**CI**	7062	4851	24	35	253	248	8	52	69	132	61	67
	OI	8845	8103	9	42	260	276	62	37	128	110	18	54
Low permeability soils (E2, C1, C2, C3, D5)	**CI**	6874	5175	24	35	252	248	1	7	44	76	90	106
	OI	9430	8472	8	42	279	286	8	3	53	41	31	64
Alfalfa (2016)													
Shallow / high permeability soils (B6, A4, D4)	**CI**		15587		91		793		0.5		21		7
	OI		17824		169		1181		0.3		12		4
Low permeability soils (E2, C1, C2, C3, D5)	**CI**		15873		91		793		0.0		0		7
	OI		18154		162		1118		0.0		0		5

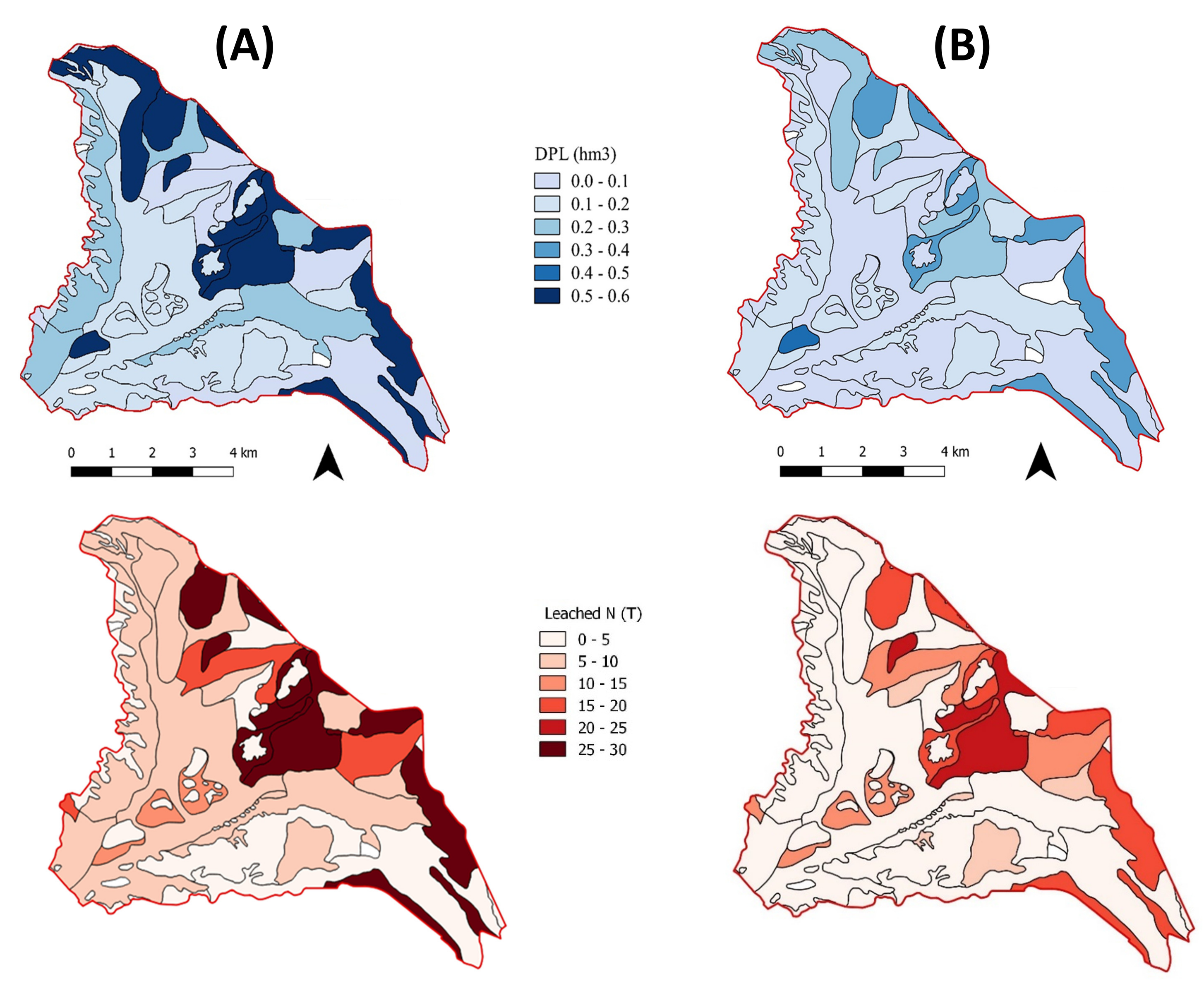

Figure 2. Spatial distribution of average total deep percolation losses (DPL, hm³) and leached N (T) under current irrigation (A) and optimal irrigation (B) in the VID.

Acknowledgments

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Conclusions

- Despite the recent modernization of the VID, it has been identified that the farmers' current irrigation practices could be improved.
- The DSSAT model demonstrated good performance for simulating the main crops in intensive cropping systems under Mediterranean conditions.
- The optimal irrigation management scenario significantly improved the irrigation water use by adjusting the irrigation water applied according the actual evapotranspiration needs and the soil holding capacity.

References

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