New insights into fertilisation with animal manures for annual double-cropping systems in nitrate vulnerable zones of northeastern Spain

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SUPPLEMENTARY MATERIAL

Figure S1. Average daily temperature and daily precipitation during the experimental period (SIAR network Z21_Tauste station)

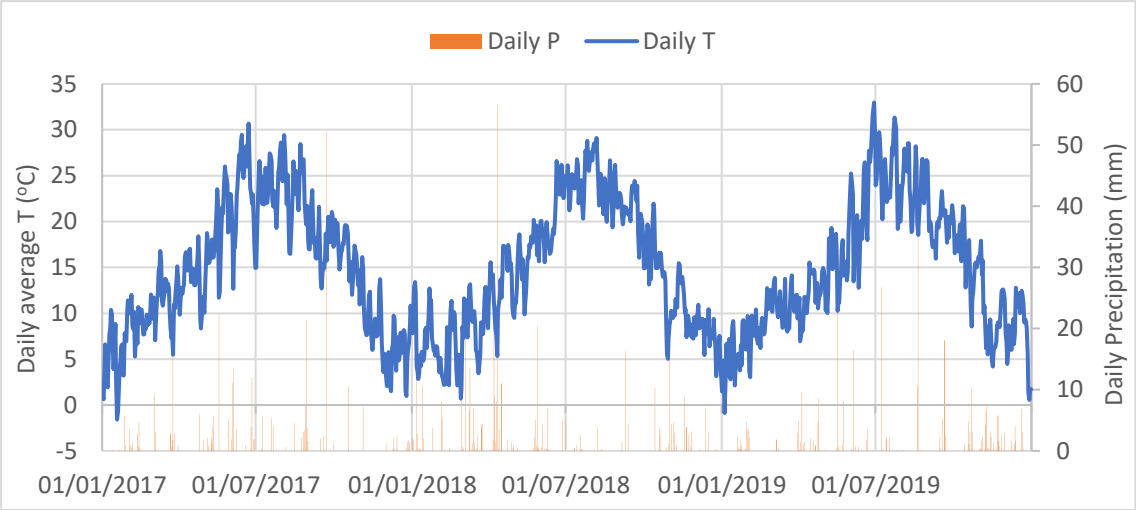

Figure S2. Pig slurry N total concentration estimated in the field by conductimetry and determined in laboratory.

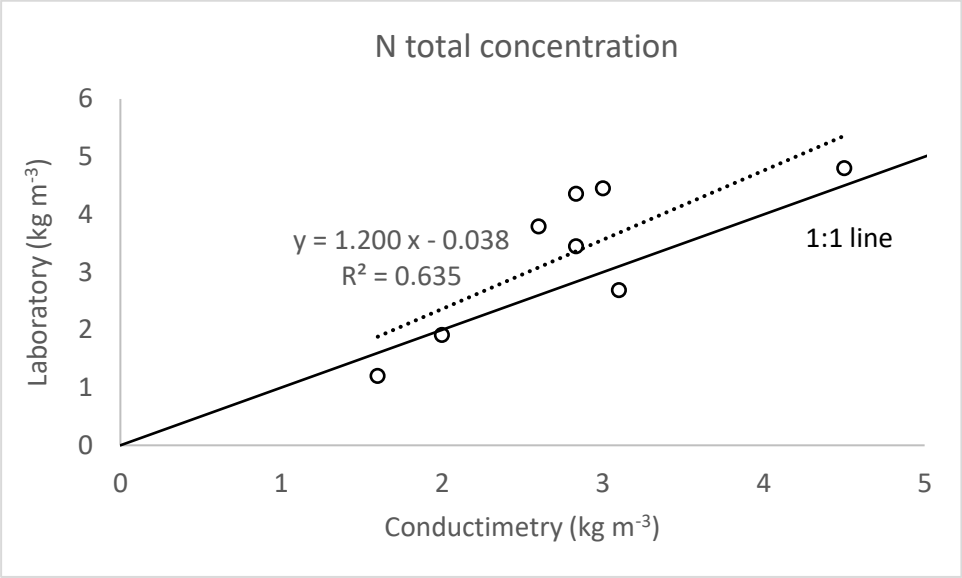

Figure S3. Ceramic suction cups. Installation in the field and extraction of the soil solution.

Table S1. Nutrient concentration in pig slurry (Total N, P_2O_5 and K_2O, kg m^{-3}) applied to the pig slurry treatment in the different crops and years at the two sites.

		Total N kg m^{-3}	P_2O_5 kg m^{-3}	K_2O kg m^{-3}	Total N kg m^{-3}	P_2O_5 kg m^{-3}	K_2O kg m^{-3}
Site	**Year**	**Winter crop**			**Summer crop**		
Barluenga	2017	4.80	0.49	6.91	4.45	4.47	3.02
	2018	1.91	0.80	1.43	2.69	1.54	1.30
	2019	4.20	4.22	2.75	-	-	-
Torremira	2017	4.36	6.44	1.86	3.45	1.40	0.99
	2018	1.20	0.15	0.90	3.79	2.95	1.47
	2019	4.20	4.22	2.75	3.31	2.26	3.56

Table S2. Average maize yields in each of the three years, at the two sites and for the two treatments (P: pig slurry, M: synthetic fertilizer). N indicates the number of data points used to calculate the mean. In the same column, average yields followed by the same letter are not significantly different (Tukey's test).

Year	N	Maize yield (kg ha^{-1})
2017	16	10812 b
2018	16	10128 ab
2019	8	9273 a
p[1]		*0.00*

Sites	N	Maize yield (kg ha^{-1})
Barluenga	16	10019
Torremira	24	10189
p[1]		*ns*

Treatment		Maize yield (kg ha^{-1})
P	20	10412
M	20	9796
p[1]		*ns*

[1] Probability level of the treatment effect after ANOVA. ns: not significant, $p > 0.05$

Table S3. Average wheat yields in Barluenga in each of the years and for the two treatments (P: pig slurry, M: synthetic fertilizer). N indicates the number of data points used to calculate the mean. In the same column, average yields followed by the same letter are not significantly different (Tukey's test).

Year	N	Yield (kg ha^{-1})
2017	8	4925 a
2018	8	5712 b
2019	8	7243 c
p[1]		*0.000*

Treatment	N	Yield (kg ha^{-1})
P	12	6113
M	12	5807
		-
		ns

[1] Probability level of the treatment effect after ANOVA. ns: not significant, $p > 0.05$

Table S4. Average green pea yields in Torremira in each of the years and for the two treatments (P: pig slurry, M: synthetic fertilizer). N indicates the number of data points used to calculate the mean. In the same column, average yields followed by the same letter are not significantly different (Tukey's test).

Year	N	Yield (kg ha^{-1})
2017	7	6540
2018	8	5932
p[1]		ns

Treatment	N	Yield (kg ha^{-1})
P	7	5920
M	8	6475
		ns

[1] Probability level of the treatment effect after ANOVA. ns: not significant, $p > 0.05$

Table S5. Average values of the nitrogen use efficiency in the two treatments for each combination of crop × year.

		Barluenga		Torremira	
Treatment	**Year**	**Wheat**	**Maize**	**Greenpea[2]**	**Maize**
P	2017	1.20	0.60	0.98	0.69
M	2017	1.05	0.80	5.39	0.70
p[1]		*ns*	*0.043*	-	*ns*
P	2018	1.02	0.52	2.50	0.50
M	2018	0.99	0.58	∞	0.58
p[1]		*ns*	*ns*	-	*ns*
P	2019	0.72		0.80	0.53
M	2019	1.28		0.90	0.54
p[1]		*0.01*		*ns*	*ns*
P	Total period	0.74		0.79	
M	Total period	0.88		1.01	
p[1]		*ns*		*ns*	

[1] Probability level of the treatment effect after ANOVA. ns: not significant, $p > 0.05$

[2] Barley in 2019