Yield, content, and nutrient uptake by winter wheat and spring barley in response to applications of digestate, cattle slurry, and NPK mineral fertilizers

Przemysław Barłóg Lukáš Hlisnikovský and Eva Kunzová

Supplemental material

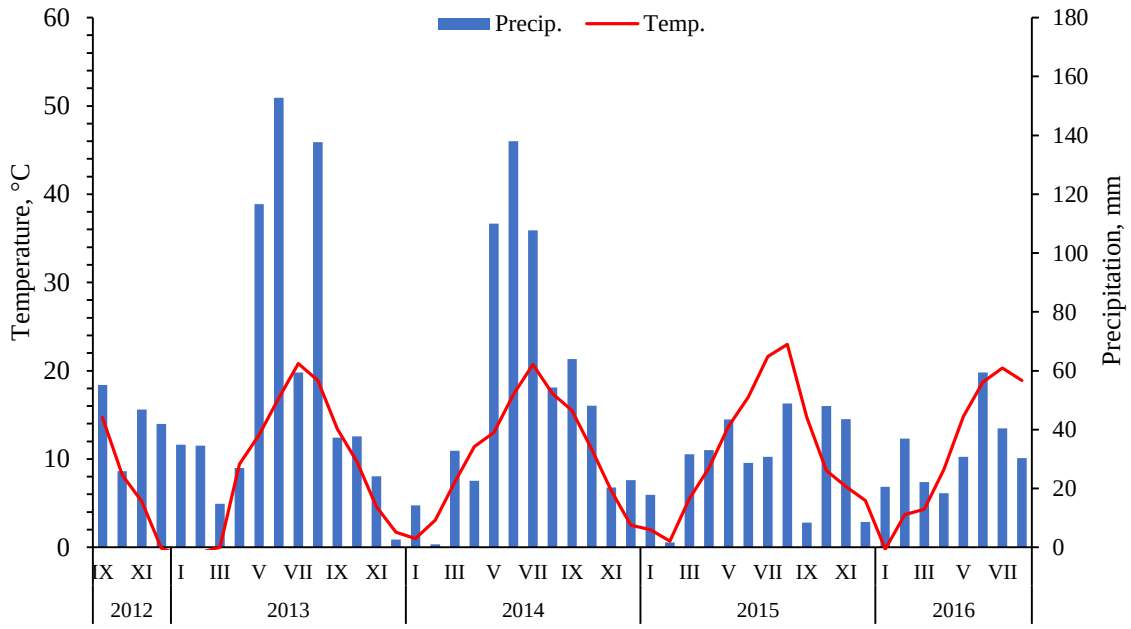

Figure S1. Mean monthly air temperature and sum of precipitation during 2012–2016 growing seasons of winter wheat and spring barley. Prague-Ruzyně Meteorological Station.

Table S1. Effect of the year and fertilization treatments on total aboveground dry matter (TDM) and harvest index (HI) of winter wheat (WW) and spring barley (SB)

Parameter	Treatment	Year / crop				Mean for WW
		2013/WW	2014/WW	2015/SB	2016/WW	
TDM, t ha^{-1}	Control	11.5±0.3 ^{b}	10.4±0.2 ^{b}	8.1±0.1 ^{c}	8.5±0.4 ^{b}	10.1±0.4 ^{c}
	Dig	15.4±0.5 ^{a}	17.9±0.5 ^{a}	12.9±0.2 ^{ab}	16.5±0.4 ^{a}	16.6±0.4 ^{a}
	Dig+S	14.7±0.5 ^{a}	16.7±0.3 ^{a}	12.8±0.1 ^{ab}	15.6±0.4 ^{a}	15.7±0.3 ^{b}
	Csl	14.9±0.5 ^{a}	17.9±0.3 ^{a}	12.6±0.2 ^{b}	15.9±0.5 ^{a}	16.2±0.4 ^{ab}
	NPK	13.8±0.4 ^{a}	17.8±0.2 ^{a}	13.5±0.1 ^{a}	15.4±0.3 ^{a}	15.7±0.5 ^{b}
HI, %	Control	58.0±0.7	54.9±1.0	60.4±0.7 ^{ab}	58.4±0.8	57.1±0.7
	Dig	55.3±1.2	55.2±0.9	57.6±0.5 ^{bc}	58.8±0.6	56.5±0.7
	Dig+S	56.6±0.9	55.9±0.4	60.5±0.4 ^{a}	59.6±0.7	57.4±0.6
	Csl	55.9±1.3	54.3±0.3	59.1±1.0 ^{abc}	59.8±1.1	56.7±0.9
	NPK	56.5±0.8	54.9±0.6	56.8±0.4 ^{c}	60.5±0.4	57.3±0.8

Treatments with the standard errors of the mean (*SEM*) followed by the same letter were not significantly different at 0.05 probability level.

Table S2. Effect of fertilization treatments on nutrient content of grain depending on the year and crop: WW – winter wheat; SB – spring barley

Year/crop	Treatment	Macronutrients + sodium, g kg^{-1}							Micronutrients, g kg^{-1}			
		N	P	K	Mg	S	Ca	Na	Zn	Cu	Mn	Fe
2013/WW	Control	18.0 ±0.35 ^{c}	3.66 ±0.07	3.98 ±0.06 ^{a}	1.18 ±0.02	1.20 ±0.01 ^{b}	1.36 ±0.01	0.10 ±0.002	24.6 ±0.3 ^{c}	4.56 ±0.04 ^{b}	40.3 ±0.4 ^{b}	31.4 ±0.6 ^{b}
	Dig	20.8 ±0.07 ^{b}	3.59 ±0.05	3.57 ±0.05 ^{b}	1.27 ±0.03	1.45 ±0.01 ^{a}	1.34 ±0.03	0.09 ±0.003	33.0 ±1.3 ^{a}	5.14 ±0.05 ^{a}	45.1 ±0.5 ^{a}	38.6 ±0.9 ^{a}
	Dig+S	22.3 ±0.28 ^{a}	3.82 ±0.08	3.72 ±0.06 ^{b}	1.25 ±0.01	1.41 ±0.01 ^{a}	1.33 ±0.02	0.09 ±0.002	30.3 ±0.7 ^{ab}	5.06 ±0.09 ^{a}	43.4 ±0.4 ^{a}	38.1 ±0.8 ^{a}
	Csl	21.4 ±0.16 ^{ab}	3.65 ±0.07	3.53 ±0.05 ^{b}	1.26 ±0.03	1.43 ±0.01 ^{a}	1.32 ±0.02	0.09 ±0.002	31.3 ±0.6 ^{ab}	5.12 ±0.08 ^{a}	43.8 ±0.3 ^{a}	38.2 ±0.3 ^{a}
	NPK	21.6 ±0.20 ^{ab}	3.84 ±0.05	3.75 ±0.06 ^{b}	1.26 ±0.03	1.41 ±0.01 ^{a}	1.36 ±0.03	0.09 ±0.003	29.5 ±0.4 ^{b}	5.14 ±0.07 ^{a}	44.5 ±0.8 ^{a}	37.4 ±0.6 ^{a}
2014/WW	Control	10.6 ±0.27 ^{b}	3.43 ±0.04	4.35 ±0.06	1.08 ±0.01	0.84 ±0.01 ^{b}	0.73 ±0.00	0.10 ±0.002	17.1 ±0.2 ^{b}	2.55 ±0.06 ^{b}	33.3 ±0.5	25.7 ±4.0
	Dig	15.8 ±0.40 ^{a}	3.40 ±0.04	4.19 ±0.04	1.07 ±0.01	1.13 ±0.01 ^{a}	0.73 ±0.01	0.10 ±0.003	20.5 ±0.2 ^{a}	3.20 ±0.03 ^{a}	33.0 ±0.4	31.3 ±5.0
	Dig+S	13.5 ±1.05 ^{a}	3.45 ±0.02	4.27 ±0.08	1.08 ±0.01	0.92 ±0.02 ^{b}	0.73 ±0.02	0.10 ±0.003	18.9 ±0.5 ^{ab}	2.82 ±0.08 ^{b}	35.4 ±1.8	23.7 ±0.1
	Csl	15.2 ±0.41 ^{a}	3.46 ±0.07	4.26 ±0.07	1.08 ±0.02	1.03 ±0.02 ^{a}	0.73 ±0.01	0.10 ±0.001	19.5 ±0.5 ^{a}	3.16 ±0.06 ^{a}	34.5 ±1.3	26.2 ±0.8
	NPK	15.1 ±0.11 ^{a}	3.58 ±0.18	4.39 ±0.24	1.10 ±0.03	1.03 ±0.03 ^{a}	0.72 ±0.01	0.09 ±0.001	19.2 ±0.6 ^{a}	3.14 ±0.09 ^{a}	35.8 ±1.3	28.3 ±2.0
2015/SB	Control	12.4 ±0.39 ^{d}	3.19 ±0.03	4.83 ±0.04	1.26 ±0.01	0.95 ±0.02 ^{d}	1.00 ±0.02	0.13 ±0.001^{c}	22.9 ±0.1 ^{c}	4.33 ±0.06 ^{b}	12.1 ±0.1	25.6 ±0.4 ^{c}
	Dig	18.4 ±0.37 ^{a}	3.14 ±0.05	4.99 ±0.14	1.29 ±0.03	1.25 ±0.02 ^{a}	1.02 ±0.03	0.17 ±0.010^{a}	29.8 ±1.2 ^{a}	5.53 ±0.16 ^{a}	12.6 ±0.6	34.0 ±1.3 ^{a}
	Dig+S	15.0 ±0.24 ^{c}	3.19 ±0.07	4.98 ±0.06	1.24 ±0.02	1.07 ±0.01 ^{c}	0.97 ±0.01	0.14 ±0.004^{bc}	26.2 ±0.6 ^{bc}	5.07 ±0.12 ^{a}	11.7 ±0.2	29.8 ±1.0 ^{bc}
	Csl	16.9 ±0.29 ^{b}	3.16 ±0.04	4.93 ±0.07	1.25 ±0.01	1.18 ±0.01 ^{b}	0.97 ±0.02	0.15 ±0.004^{bc}	27.1 ±0.3 ^{ab}	5.07 ±0.04 ^{a}	11.7 ±0.3	31.0 ±0.6 ^{ab}
	NPK	18.1 ±0.32 ^{ab}	3.12 ±0.05	4.89 ±0.14	1.27 ±0.00	1.18 ±0.01 ^{b}	0.98 ±0.01	0.16 ±0.006^{ab}	26.9 ±1.1 ^{ab}	5.56 ±0.14 ^{a}	12.5 ±0.2	32.0 ±0.7 ^{ab}
2016/WW	Control	11.2 ±0.18 ^{c}	3.23 ±0.03 ^{a}	4.13 ±0.04 ^{a}	1.04 ±0.02 ^{ab}	0.86 ±0.02 ^{c}	0.56 ±0.01	0.07 ±0.002^{b}	16.1 ±0.2 ^{ab}	2.98 ±0.05 ^{b}	33.6 ±0.4 ^{ab}	26.7 ±0.5 ^{b}
	Dig	17.1 ±0.48 ^{a}	2.98 ±0.05 ^{bc}	3.41 ±0.05 ^{bc}	1.05 ±0.01 ^{a}	1.24 ±0.02 ^{a}	0.57 ±0.01	0.11 ±0.010^{a}	17.6 ±0.4 ^{a}	3.64 ±0.06 ^{a}	32.2 ±0.5 ^{ab}	32.7 ±0.8 ^{a}
	Dig+S	15.6 ±0.32 ^{b}	3.13 ±0.08 ^{ab}	3.57 ±0.06 ^{b}	1.04 ±0.01 ^{ab}	1.14 ±0.01 ^{b}	0.55 ±0.02	0.07 ±0.004^{b}	17.4 ±0.6 ^{a}	3.53 ±0.08 ^{a}	32.9 ±1.6 ^{ab}	31.2 ±1.4 ^{a}
	Csl	16.0 ±0.39 ^{ab}	3.18 ±0.06 ^{ab}	3.65 ±0.06 ^{ba}	1.08 ±0.01 ^{a}	1.19 ±0.02 ^{ab}	0.57 ±0.00	0.07 ±0.002^{b}	17.9 ±0.7 ^{a}	3.67 ±0.03 ^{a}	35.3 ±1.3 ^{a}	32.6 ±0.6 ^{a}
	NPK	16.8 ±0.25 ^{ab}	2.81 ±0.05 ^{c}	3.26 ±0.07 ^{c}	0.98 ±0.02 ^{b}	1.18 ±0.01 ^{ab}	0.52 ±0.02	0.07 ±0.003^{b}	14.5 ±0.6 ^{b}	3.16 ±0.08 ^{b}	28.9 ±1.9 ^{b}	29.4 ±0.8 ^{ab}
mean/WW	Control	13.3 ±1.03 ^{b}	3.44 ±0.06	4.15 ±0.05 ^{a}	1.10 ±0.02	0.96 ±0.05 ^{d}	0.88 ±0.10	0.09 ±0.004^{b}	19.3 ±1.2 ^{d}	3.36 ±0.26 ^{c}	35.7 ±1.0	27.9 ±1.4 ^{b}
	Dig	17.9 ±0.66 ^{a}	3.33 ±0.08	3.72 ±0.10 ^{b}	1.13 ±0.03	1.27 ±0.04 ^{a}	0.88 ±0.10	0.10 ±0.004^{a}	23.7 ±2.1 ^{a}	3.99 ±0.25 ^{a}	36.7 ±1.8	34.2 ±1.8 ^{a}
	Dig+S	17.1 ±1.19 ^{a}	3.47 ±0.09	3.85 ±0.10 ^{b}	1.12 ±0.03	1.16 ±0.06 ^{c}	0.87 ±0.10	0.09 ±0.004 ^{b}	22.2 ±1.8 ^{bc}	3.80 ±0.28 ^{b}	37.2 ±1.5	31.0 ±1.8 ^{ab}
	Csl	17.5 ±0.85 ^{a}	3.43 ±0.07	3.81 ±0.10 ^{b}	1.14 ±0.03	1.22 ±0.05 ^{b}	0.87 ±0.10	0.09 ±0.004 ^{b}	22.9 ±1.8 ^{ab}	3.98 ±0.25 ^{a}	37.9 ±1.4	32.3 ±1.5 ^{a}
	NPK	17.8 ±0.84 ^{a}	3.41 ±0.14	3.80 ±0.16 ^{b}	1.11 ±0.04	1.21 ±0.05 ^{b}	0.87 ±0.11	0.08 ±0.004 ^{b}	21.1 ±1.9 ^{b}	3.81 ±0.29 ^{b}	36.4 ±2.0	31.7 ±1.4 ^{ab}

Treatments with the standard errors of the mean (*SEM*) followed by the same letter were not significantly different at 0.05 probability level.

Table S3. Effect of fertilization treatments on nutrient content of straw depending on the year and crop: WW – winter wheat; SB – spring barley

Year/crop	Treatment	Macronutrients + sodium, g kg^{-1}							Micronutrients, g kg^{-1}			
		N	P	K	Mg	S	Ca	Na	Zn	Cu	Mn	Fe
2013/WW	Control	2.43 ±0.08^{b}	0.43 ±0.02^{b}	6.19 ±0.27^{b}	0.61 ±0.00^{b}	0.46 ±0.01^{b}	3.30 ±0.07^{b}	0.11 ±0.001	5.8 ±0.4^{c}	2.09 ±0.03^{b}	26.3 ±0.6	72.5 ±7.3^{a}
	Dig	3.90 ±0.41^{a}	0.64 ±0.08^{a}	7.93 ±0.49^{ab}	0.70 ±0.02^{a}	0.62 ±0.05^{a}	3.50 ±0.05^{ab}	0.11 ±0.003	9.3 ±0.6^{ab}	2.39 ±0.08^{a}	25.3 ±2.2	53.3 ±4.3^{ab}
	Dig+S	3.90 ±0.25^{a}	0.67 ±0.04^{a}	8.28 ±0.67^{a}	0.69 ±0.01^{a}	0.63 ±0.05^{a}	3.49 ±0.09^{ab}	0.11 ±0.002	9.8 ±0.9^{ab}	2.49 ±0.11^{a}	24.6 ±0.1	51.9 ±2.7^{ab}
	Csl	3.82 ±0.20^{a}	0.66 ±0.05^{a}	8.61 ±0.26^{a}	0.70 ±0.01^{a}	0.64 ±0.03^{a}	3.61 ±0.07^{a}	0.11 ±0.003	11.3 ±0.9^{a}	2.47 ±0.04^{a}	25.6 ±1.6	47.0 ±0.6^{b}
	NPK	3.54 ±0.10^{a}	0.60 ±0.02^{ab}	7.44 ±0.19^{ab}	0.67 ±0.01^{a}	0.54 ±0.02^{ab}	3.46 ±0.00^{ab}	0.12 ±0.004	7.2 ±0.7^{bc}	2.30 ±0.01^{ab}	25.2 ±0.4	52.6 ±6.0^{ab}
2014/WW	Control	2.06 ±0.13^{b}	0.43 ±0.02^{a}	4.68 ±0.03^{b}	0.61 ±0.01^{a}	0.53 ±0.02^{a}	2.78 ±0.12	0.11 ±0.004	6.4 ±0.6	1.90 ±0.13	45.0 ±1.8^{a}	71.9 ±8.6
	Dig	2.76 ±0.20^{a}	0.34 ±0.04^{ab}	6.51 ±0.30^{a}	0.52 ±0.01^{b}	0.46 ±0.03^{ab}	2.91 ±0.16	0.15 ±0.035	7.3 ±0.7	2.02 ±0.16	30.1 ±0.8^{b}	68.7 ±13.2
	Dig+S	2.38 ±0.08^{ab}	0.35 ±0.02^{ab}	5.90 ±0.12^{a}	0.52 ±0.01^{b}	0.42 ±0.01^{b}	2.66 ±0.09	0.12 ±0.012	6.3 ±0.8	1.93 ±0.03	34.0 ±2.3^{b}	48.4 ±7.7
	Csl	2.43 ±0.10^{ab}	0.32 ±0.02^{b}	6.14 ±0.27^{a}	0.55 ±0.01^{b}	0.43 ±0.01^{b}	3.07 ±0.04	0.12 ±0.004	5.6 ±0.5	2.24 ±0.24	33.7 ±1.6^{b}	49.7 ±1.1
	NPK	2.52 ±0.06^{ab}	0.30 ±0.02^{b}	6.05 ±0.04^{a}	0.47 ±0.00^{c}	0.41 ±0.00^{b}	2.78 ±0.05	0.11 ±0.006	5.4 ±0.5	2.01 ±0.06	29.6 ±1.3^{b}	40.7 ±5.7
2015/SB	Control	2.69 ±0.06^{c}	0.43 ±0.04	12.4 ±0.60^{c}	0.67 ±0.02^{ab}	0.90 ±0.03^{a}	4.68 ±0.14^{ab}	0.52 ±0.050^{c}	3.9 ±0.1^{b}	1.98 ±0.08^{d}	13.1 ±0.8	16.9 ±0.5
	Dig	5.80 ±0.47^{a}	0.42 ±0.05	21.7 ±0.98^{a}	0.74 ±0.03^{a}	0.82 ±0.05^{ab}	4.84 ±0.14^{a}	1.99 ±0.168^{a}	6.6 ±0.4^{a}	2.81 ±0.07^{a}	14.7 ±0.9	20.2 ±0.5
	Dig+S	3.52 ±0.27^{bc}	0.36 ±0.03	19.1 ±0.53^{ab}	0.63 ±0.01^{b}	0.63 ±0.02^{c}	4.34 ±0.07^{b}	1.32 ±0.119^{b}	5.3 ±0.6^{ab}	2.14 ±0.07^{cd}	11.5 ±0.2	16.8 ±1.6
	Csl	4.57 ±0.18^{b}	0.32 ±0.02	17.3 ±0.59^{b}	0.69 ±0.02^{ab}	0.73 ±0.02^{bc}	4.41 ±0.05^{ab}	1.43 ±0.141^{b}	5.7 ±0.4^{a}	2.55 ±0.06^{ab}	14.8 ±0.8	16.8 ±0.3
	NPK	4.21 ±0.18^{b}	0.32 ±0.02	19.0 ±0.35^{ab}	0.72 ±0.02^{a}	0.65 ±0.01^{c}	4.64 ±0.08^{ab}	1.77 ±0.047^{ab}	4.9 ±0.4^{ab}	2.37 ±0.05^{bc}	14.4 ±1.1	19.3 ±1.4
2016/WW	Control	1.66 ±0.04^{b}	0.28 ±0.02^{a}	6.04 ±0.14^{b}	0.59 ±0.01	0.47 ±0.02^{ab}	1.73 ±0.05^{b}	0.08 ±0.001^{c}	4.1 ±0.1^{a}	1.36 ±0.02^{b}	38.4 ±1.1^{a}	22.3 ±1.9
	Dig	2.39 ±0.12^{a}	0.19 ±0.01^{b}	10.05 ±0.55^{a}	0.59 ±0.01	0.49 ±0.04^{ab}	1.99 ±0.05^{a}	0.12 ±0.012^{a}	3.2 ±0.2^{ab}	1.69 ±0.03^{a}	26.9 ±0.9^{c}	20.4 ±1.6
	Dig+S	2.26 ±0.15^{a}	0.23 ±0.02^{ab}	9.50 ±0.24^{a}	0.60 ±0.01	0.45 ±0.03^{b}	1.99 ±0.05^{a}	0.11±0.004^{ab}	3.4 ±0.1^{ab}	1.60 ±0.03^{a}	29.6 ±0.7^{bc}	18.9 ±0.8
	Csl	2.40 ±0.17^{a}	0.24 ±0.01^{ab}	9.34 ±0.62^{a}	0.62 ±0.01	0.59 ±0.05^{a}	2.17 ±0.08^{a}	0.09 ±0.009^{bc}	3.9 ±0.5^{ab}	1.71 ±0.04^{a}	32.5 ±0.6^{b}	21.5 ±1.0
	NPK	2.33 ±0.07^{a}	0.19 ±0.01^{a}	9.07 ±0.05^{a}	0.60 ±0.01	0.42 ±0.01^{b}	2.10 ±0.05^{a}	0.10 ±0.004^{ab}	3.0 ±0.1^{b}	1.63 ±0.04^{a}	33.7 ±2.0^{ab}	21.4 ±1.4
mean/WW	Control	2.05 ±0.11^{b}	0.38 ±0.02	5.64 ±0.22^{b}	0.60 ±0.01^{ab}	0.49 ±0.01^{ab}	2.60 ±0.20^{c}	0.10 ±0.005^{b}	5.4 ±0.4^{bc}	1.78 ±0.10^{b}	36.6 ±2.4^{a}	55.6 ±7.9^{a}
	Dig	3.01 ±0.24^{a}	0.39 ±0.06	8.16 ±0.50^{a}	0.60 ±0.02^{ab}	0.53 ±0.03^{ab}	2.80 ±0.19^{ab}	0.13 ±0.013^{a}	6.6 ±0.8^{ab}	2.03 ±0.10^{a}	27.4 ±1.0^{b}	47.5 ±7.4^{ab}
	Dig+S	2.85 ±0.24^{a}	0.42 ±0.06	7.89 ±0.50^{a}	0.60 ±0.02^{ab}	0.50 ±0.03^{ab}	2.71 ±0.19^{bc}	0.12 ±0.004^{ab}	6.5 ±0.9^{abc}	2.01 ±0.12^{a}	29.4 ±1.4^{b}	39.7 ±5.1^{b}
	Csl	2.88 ±0.22^{a}	0.41 ±0.06	8.03 ±0.47^{a}	0.62 ±0.02^{a}	0.55 ±0.03^{a}	2.95 ±0.18^{a}	0.11 ±0.004^{ab}	6.9 ±1.0^{a}	2.14 ±0.12^{a}	30.6 ±1.3^{b}	39.4 ±3.9^{b}
	NPK	2.80 ±0.17^{a}	0.36 ±0.05	7.52 ±0.38^{a}	0.58 ±0.03^{b}	0.46 ±0.02^{b}	2.78 ±0.17^{ab}	0.11 ±0.004^{ab}	5.2 ±0.6^{c}	1.98 ±0.09^{ab}	29.5 ±1.3^{b}	38.2 ±4.6^{b}

Treatments with the standard errors of the mean (*SEM*) followed by the same letter were not significantly different at 0.05 probability level.

Table S4. Effect of fertilization treatments on total nutrient uptake by winter wheat (WW) and spring barley (SB) depending on the year

Year/crop	Treatment	Macronutrients + sodium, kg ha^{-1}							Micronutrients, g ha^{-1}			
		N	P	K	Mg	S	Ca	Na	Zn	Cu	Mn	Fe
2013/WW	Control	132.7 ±4.9^{b}	26.6 ±0.7^{b}	56.8 ±2.6^{b}	10.9 ±0.4^{b}	10.2 ±0.4^{c}	25.1 ±1.0^{b}	1.2 ±0.02^{b}	193 ±5.1^{c}	40.7 ±1.0^{c}	398 ±13.6^{b}	562 ±34.0
	Dig	203.1 ±0.8^{a}	34.9 ±0.5^{a}	85.0 ±4.0^{a}	15.6 ±0.3^{a}	16.6 ±0.1^{a}	35.7 ±1.6^{a}	1.6 ±0.07^{a}	345 ±11.0^{a}	60.2 ±0.7^{a}	557 ±16.0^{a}	695 ±28.7
	Dig+S	211.0 ±7.9^{a}	36.1 ±0.8^{a}	84.4 ±7.4^{a}	14.8 ±0.4^{a}	15.8 ±0.7^{ab}	33.4 ±1.8^{a}	1.5 ±0.06^{a}	314 ±8.4^{a}	58.1 ±2.3^{ab}	518 ±13.9^{a}	650 ±34.5
	Csl	202.5 ±4.5^{a}	34.6 ±1.1^{a}	86.1 ±5.4^{a}	15.1 ±0.5^{a}	16.1 ±0.6^{ab}	34.6 ±1.4^{a}	1.5 ±0.04^{a}	334 ±6.6^{a}	58.7 ±1.1^{ab}	532 ±18.1^{a}	625 ±25.8
	NPK	190.3 ±4.5^{a}	33.7 ±0.5^{a}	74.2 ±2.3^{ab}	13.9 ±0.3^{a}	14.3 ±0.3^{b}	31.5 ±1.0^{a}	1.4 ±0.05^{a}	273 ±2.5^{b}	54.0 ±1.0^{b}	499 ±14.0^{a}	610 ±43.2
2014/WW	Control	69.9 ±3.6^{c}	21.5 ±0.5^{b}	46.6 ±0.7^{b}	9.0 ±0.2^{b}	7.2 ±0.2^{c}	17.1 ±0.5^{c}	1.0 ±0.05^{b}	127 ±4.7^{c}	23.4 ±1.3^{c}	399 ±13.3^{b}	486 ±73.1^{b}
	Dig	178.0 ±7.4^{a}	36.3 ±0.2^{a}	93.6 ±4.0^{a}	14.8 ±0.4^{a}	14.8 ±0.4^{a}	30.5 ±1.1^{a}	2.2 ±0.36^{a}	261 ±8.7^{a}	47.6 ±0.4^{a}	567 ±15.0^{a}	865 ±126.0^{a}
	Dig+S	143.4 ±9.9^{b}	34.8 ±0.5^{a}	83.4 ±2.5^{a}	13.9 ±0.3^{a}	11.7 ±0.3^{b}	26.5 ±0.4^{b}	1.8 ±0.04^{a}	223 ±4.7^{b}	40.6 ±1.1^{b}	581 ±15.2^{a}	576 ±55.6^{ab}
	Csl	167.4 ±3.9^{ab}	36.3 ±0.8^{a}	91.8 ±3.4^{a}	15.0 ±0.2^{a}	13.5 ±0.2^{a}	32.4 ±1.0^{a}	1.9 ±0.04^{a}	236 ±9.4^{ab}	49.2 ±2.9^{a}	612 ±24.8^{a}	662 ±12.1^{ab}
	NPK	168.1 ±1.9^{ab}	37.5 ±1.9^{a}	91.8 ±2.1^{a}	14.6 ±0.4^{a}	13.4 ±0.5^{a}	29.4 ±0.9^{ab}	1.8 ±0.08^{a}	231 ±7.1^{ab}	46.9 ±1.0^{ab}	588 ±21.7^{a}	603 ±60.7^{ab}
2015/SB	Control	69.7 ±1.8^{d}	17.1 ±0.3^{b}	63.3 ±1.7^{c}	8.3 ±0.1^{c}	7.6 ±0.1^{c}	19.9 ±0.3^{c}	2.3 ±0.14^{d}	125 ±2.6^{b}	27.6 ±0.7^{c}	102 ±2.6^{c}	180 ±2.7^{c}
	Dig	168.1 ±5.7^{a}	25.5 ±0.7^{a}	155.5 ±8.0^{a}	13.6 ±0.4^{ab}	13.7 ±0.5^{a}	33.9 ±1.0^{a}	12.2 ±1.16^{a}	257 ±13.2^{a}	56.3 ±2.0^{a}	174 ±10.3^{ab}	362 ±11.9^{a}
	Dig+S	134.0 ±2.4^{b}	26.6 ±0.8^{a}	135.4 ±2.8^{ab}	12.9 ±0.2^{b}	11.5 ±0.2^{b}	29.5 ±0.6^{b}	7.8 ±0.59^{c}	230 ±5.1^{a}	50.1 ±1.1^{b}	149 ±1.4^{b}	316 ±6.0^{b}
	Csl	149.7 ±4.4^{bc}	25.3 ±0.4^{a}	126.3 ±5.4^{b}	12.9 ±0.2^{b}	12.6 ±0.3^{ab}	30.1 ±0.9^{b}	8.6 ±1.01^{bc}	232 ±4.4^{a}	51.1 ±0.8^{ab}	164 ±2.7^{ab}	318 ±0.9^{b}
	NPK	163.0 ±2.5^{ab}	25.8 ±0.4^{a}	148.1 ±1.1^{ab}	13.9 ±0.1^{a}	12.9 ±0.2^{a}	34.5 ±0.7^{a}	11.5 ±0.32^{ab}	235 ±10.1^{a}	56.4 ±1.6^{a}	180 ±7.8^{a}	358 ±12.5^{a}
2016/WW	Control	61.2 ±1.7^{b}	16.9 ±0.6^{c}	41.6 ±1.3^{b}	7.2 ±0.3^{b}	5.9 ±0.3^{b}	8.9 ±0.6^{b}	0.6 ±0.03^{c}	94 ±4.1^{c}	19.5 ±1.0^{c}	302 ±17.9^{b}	210 ±6.4^{b}
	Dig	182.4 ±7.8^{a}	30.2 ±0.9^{ab}	101.5 ±6.3^{a}	14.2 ±0.3^{a}	15.3 ±0.7^{a}	19.0 ±0.6^{a}	1.9 ±0.03^{a}	192 ±7.8^{a}	46.7 ±1.5^{a}	494 ±10.4^{a}	454 ±5.8^{a}
	Dig+S	159.9 ±6.4^{a}	30.6 ±1.1^{ab}	93.5 ±4.6^{a}	13.5 ±0.4^{a}	13.4 ±0.5^{a}	17.7 ±0.8^{a}	1.4 ±0.06^{b}	183 ±6.7^{ab}	43.0 ±1.2^{ab}	493 ±19.1^{a}	410 ±20.4^{a}
	Csl	167.6 ±7.6^{a}	31.8 ±1.1^{a}	95.1 ±7.2^{a}	14.2 ±0.4^{a}	15.1 ±0.9^{a}	19.4 ±1.3^{a}	1.3 ±0.09^{b}	195 ±11.2^{a}	45.9 ±1.6^{a}	545 ±20.7^{a}	447 ±15.9^{a}
	NPK	170.7 ±3.6^{a}	27.3 ±0.9^{b}	85.6 ±2.6^{a}	12.8 ±0.4^{a}	13.5 ±0.3^{a}	17.7 ±0.7^{a}	1.2 ±0.04^{b}	153 ±8.5^{b}	39.4 ±1.3^{b}	476 ±36.3^{a}	404 ±21.7^{a}
mean/WW	Control	87.9 ±9.8^{c}	21.7 ±1.2^{b}	48.3 ±2.1^{b}	9.0 ±0.5^{c}	7.8 ±0.6^{c}	17.0 ±2.0^{d}	0.9 ±0.07^{c}	138 ±12.7^{d}	27.9 ±2.8^{c}	366 ±15.8^{b}	419 ±51.7^{c}
	Dig	187.9 ±4.6^{a}	33.8 ±0.8^{a}	93.4 ±3.3^{a}	14.9 ±0.3^{a}	15.6 ±0.3^{a}	28.4 ±2.2^{ab}	1.9 ±0.14^{a}	266 ±19.4^{a}	51.5 ±1.9^{a}	539 ±12.3^{a}	671 ±64.1^{a}
	Dig+S	171.4 ±9.7^{b}	33.8 ±0.8^{a}	87.1 ±3.0^{a}	14.1 ±0.2^{ab}	13.6 ±0.6^{b}	25.9 ±2.0^{c}	1.6 ±0.07^{b}	240 ±16.9^{b}	47.2 ±2.5^{b}	531 ±14.0^{a}	546 ±36.6^{b}
	Csl	179.2 ±5.8^{ab}	34.2 ±0.8^{a}	91.0 ±3.1^{a}	14.8 ±0.2^{a}	14.9 ±0.4^{a}	28.8 ±2.1^{a}	1.6 ±0.08^{b}	255 ±18.3^{ab}	51.3 ±1.9^{a}	563 ±15.4^{a}	578 ±29.9^{ab}
	NPK	176.4 ±3.5^{ab}	32.8 ±1.4^{a}	83.9 ±2.5^{a}	13.8 ±0.3^{b}	13.7 ±0.2^{b}	26.2 ±1.9^{bc}	1.5 ±0.08^{b}	219 ±15.4^{c}	46.8 ±1.9^{b}	521 ±19.8^{a}	539 ±37.1^{b}

Treatments with the standard errors of the mean (*SEM*) followed by the same letter were not significantly different at 0.05 probability level.

Table S5. Effect of fertilization treatments on nutrient harvest indices, NuHI (%)

Year/crop	Treatment	Macronutrients + sodium							Micronutrients			
		N	P	K	Mg	S	Ca	Na	Zn	Cu	Mn	Fe
2013/WW	Control	91.1 ±0.3 [a]	92.0 ±0.6 [a]	47.2 ±1.9 [a]	72.8 ±0.4	78.3 ±0.8	36.4 ±1.1	54.7 ±0.8	85.4 ±0.9 [a]	75.1 ±0.8	68.0 ±0.5	37.9 ±3.0
	Dig	87.0 ±0.6 [b]	87.5 ±0.7 [b]	35.9 ±1.6 [b]	69.2 ±0.6	74.3 ±0.8	32.3 ±1.5	51.1 ±2.3	81.3 ±1.4 [ab]	72.7 ±0.5	69.0 ±1.4	47.5 ±1.9
	Dig+S	88.2 ±0.9 [ab]	88.0 ±1.1 [b]	37.3 ±2.9 [b]	70.1 ±1.0	74.4 ±2.3	33.3 ±1.3	51.7 ±1.6	80.3 ±1.0 [ab]	72.6 ±1.7	69.7 ±0.8	49.0 ±2.3
	Csl	87.6 ±1.1 [b]	87.6 ±1.0 [b]	34.3 ±1.7 [b]	69.5 ±1.4	74.0 ±2.0	31.7 ±1.5	50.3 ±1.6	77.7 ±2.6 [b]	72.4 ±1.4	68.5 ±2.0	50.8 ±1.4
	NPK	88.8 ±0.2 [ab]	89.2 ±0.6 [ab]	39.6 ±1.4 [ab]	70.9 ±0.6	77.2 ±0.6	33.9 ±0.9	50.7 ±0.4	84.2 ±0.7 [a]	74.4 ±0.6	69.7 ±0.5	48.5 ±3.1
2014/WW	Control	86.3 ±0.6	90.7 ±0.3 [b]	53.1 ±1.0 [a]	68.2 ±0.8 [c]	65.9 ±0.5 [b]	24.3 ±0.4 [ab]	53.0 ±1.8	76.8 ±1.4	62.2 ±1.9	47.4 ±1.2 [b]	30.2 ±2.0 [b]
	Dig	87.6 ±0.6	92.6 ±0.8 [ab]	44.4 ±1.5 [b]	71.7 ±1.2 [ab]	75.2 ±1.3 [a]	23.9 ±1.2 [ab]	45.5 ±4.8	77.7 ±1.9	66.4 ±1.1	57.5 ±1.2 [a]	37.0 ±5.3 [a]
	Dig+S	87.6 ±0.9	92.6 ±0.3 [ab]	47.9 ±0.7 [ba]	72.7 ±0.2 [ab]	73.7 ±0.3 [a]	25.9 ±0.8 [a]	50.4 ±2.6	79.1 ±2.4	65.0 ±1.1	56.9 ±2.6 [a]	39.5 ±3.7 [a]
	Csl	88.1 ±0.8	92.8 ±0.5 [ab]	45.3 ±1.4 [b]	70.0 ±0.4 [bc]	74.1 ±0.7 [a]	22.1 ±0.5 [b]	50.3 ±1.2	80.7 ±1.3 [b]	62.9 ±2.2	54.9 ±0.9 [a]	38.5 ±1.0 [a]
	NPK	88.0 ±0.5	93.5 ±0.6 [a]	46.8 ±2.0 [b]	73.9 ±0.8 [a]	75.3 ±1.0 [a]	24.1 ±0.7 [ab]	50.0 ±1.8	81.4 ±1.3	65.5 ±1.4	59.6 ±0.5 [a]	46.4 ±1.8 [a]
2015/SB	Control	87.5 ±0.6 [a]	91.9 ±0.7	37.4 ±0.8 [a]	74.2 ±0.7 [a]	61.7 ±1.7 [b]	24.6 ±0.9 [a]	27.7 ±1.2 [a]	90.1 ±0.1 [a]	76.9 ±0.7 [ab]	58.6 ±1.4 [ab]	69.7 ±1.4
	Dig	81.3 ±1.0 [b]	91.0 ±0.9	23.9 ±0.7 [b]	70.3 ±0.4 [bc]	67.5 ±1.3 [a]	22.3 ±0.9 [ab]	10.7 ±0.7 [b]	86.0 ±0.4 [ab]	72.8 ±0.5 [c]	53.8 ±1.0 [b]	69.6 ±1.1
	Dig+S	86.7 ±0.9 [a]	93.1 ±0.5	28.6 ±1.0 [b]	75.0 ±0.2 [a]	72.2 ±0.8 [a]	25.5 ±0.3 [a]	14.5 ±1.3 [b]	88.4 ±1.2 [ab]	78.4 ±1.1 [a]	60.9 ±1.0 [a]	73.1 ±2.5
	Csl	84.2 ±0.9 [ab]	93.4 ±0.6	29.3 ±1.6 [b]	72.5 ±0.8 [ab]	69.9 ±1.5 [a]	24.2 ±1.4 [ab]	13.8 ±1.6 [b]	87.3 ±0.3 [ab]	74.1 ±1.2 [bc]	53.4 ±1.1 [b]	72.6 ±1.0
	NPK	84.9 ±0.7 [a]	92.8 ±0.4	25.3 ±0.6 [b]	69.7 ±0.8 [c]	70.6 ±0.6 [a]	21.7 ±0.6 [b]	10.5 ±0.4 [b]	87.8 ±0.9 [ab]	75.5 ±0.4 [abc]	53.5 ±1.9 [b]	68.6 ±1.6
2016/WW	Control	90.5 ±0.5	94.2 ±0.6	49.0 ±0.7 [a]	71.3 ±1.1	71.8 ±1.6 [c]	31.3 ±1.2	57.1 ±1.1	84.6 ±0.6 [b]	75.5 ±0.8	55.2 ±1.3 [c]	62.9 ±2.5 [b]
	Dig	91.1 ±0.3	95.7 ±0.2	32.8 ±1.6 [b]	72.0 ±0.2	78.4 ±0.3 [ab]	29.0 ±0.4	54.8 ±5.2	88.7 ±0.5 [a]	75.5 ±0.4	63.2 ±0.6 [a]	69.7 ±1.6 [a]
	Dig+S	91.1 ±0.6	95.3 ±0.5	35.6 ±1.3 [b]	72.0 ±0.7	79.0 ±1.3 [ab]	28.9 ±1.5	49.0 ±2.5	88.4 ±0.3 [a]	76.5 ±1.0	62.0 ±1.1 [ab]	70.8 ±1.4 [a]
	Csl	90.8 ±0.8	95.1 ±0.4	37.0 ±2.7 [b]	72.0 ±1.2	74.9 ±2.0 [bc]	28.1 ±1.5	53.3 ±3.9	87.3 ±0.7 [a]	76.1 ±1.0	61.7 ±1.8 [ab]	69.3 ±0.6 [ab]
	NPK	91.7 ±0.3	95.8 ±0.3	35.5 ±0.4 [b]	71.4 ±0.6	81.1 ±0.4 [a]	27.5 ±0.8	51.0 ±2.0	88.2 ±0.4 [a]	74.8 ±0.9	56.7 ±1.4 [bc]	67.9 ±0.9 [ab]
mean/WW	Control	89.3 ±0.7	92.3 ±0.5	49.8 ±1.0 [a]	70.7 ±1.6	72.0 ±1.6 [c]	30.7 ±0.9 [a]	55.0 ±0.9	82.3 ±1.3	70.9 ±2.0	56.9 ±2.6 [b]	43.7 ±4.4 [b]
	Dig	88.6 ±0.6	91.9 ±1.1	37.7 ±1.7 [b]	71.0 ±0.8	75.9 ±1.2 [ab]	28.4 ±2.5 [ab]	50.5 ±2.5	82.6 ±1.6	71.5 ±1.2	63.2 ±1.5 [a]	51.4 ±4.5 [a]
	Dig+S	89.0 ±0.5	92.0 ±0.9	40.3 ±1.6 [b]	71.6 ±0.8	75.7 ±1.3 [ab]	29.4 ±0.8 [ab]	50.3 ±0.8	82.6 ±1.0	71.3 ±1.4	62.9 ±1.7 [a]	53.1 ±3.1 [a]
	Csl	88.8 ±0.6	91.8 ±1.0	38.9 ±1.9 [b]	70.5 ±1.1	74.3 ±1.1 [bc]	27.3 ±1.2 [b]	51.3 ±1.2	81.9 ±1.5	70.5 ±1.6	61.7 ±1.8 [a]	52.8 ±4.2 [a]
	NPK	89.5 ±0.6	92.8 ±1.0	40.7 ±1.7 [b]	72.0 ±1.4	77.9 ±1.4 [a]	28.5 ±1.4 [ab]	50.6 ±1.4	84.6 ±1.5	71.6 ±1.9	62.0 ±1.9 [a]	54.3 ±3.9 [a]

Treatments with the standard errors of the mean (*SEM*) followed by the same letter were not significantly different at 0.05 probability level.

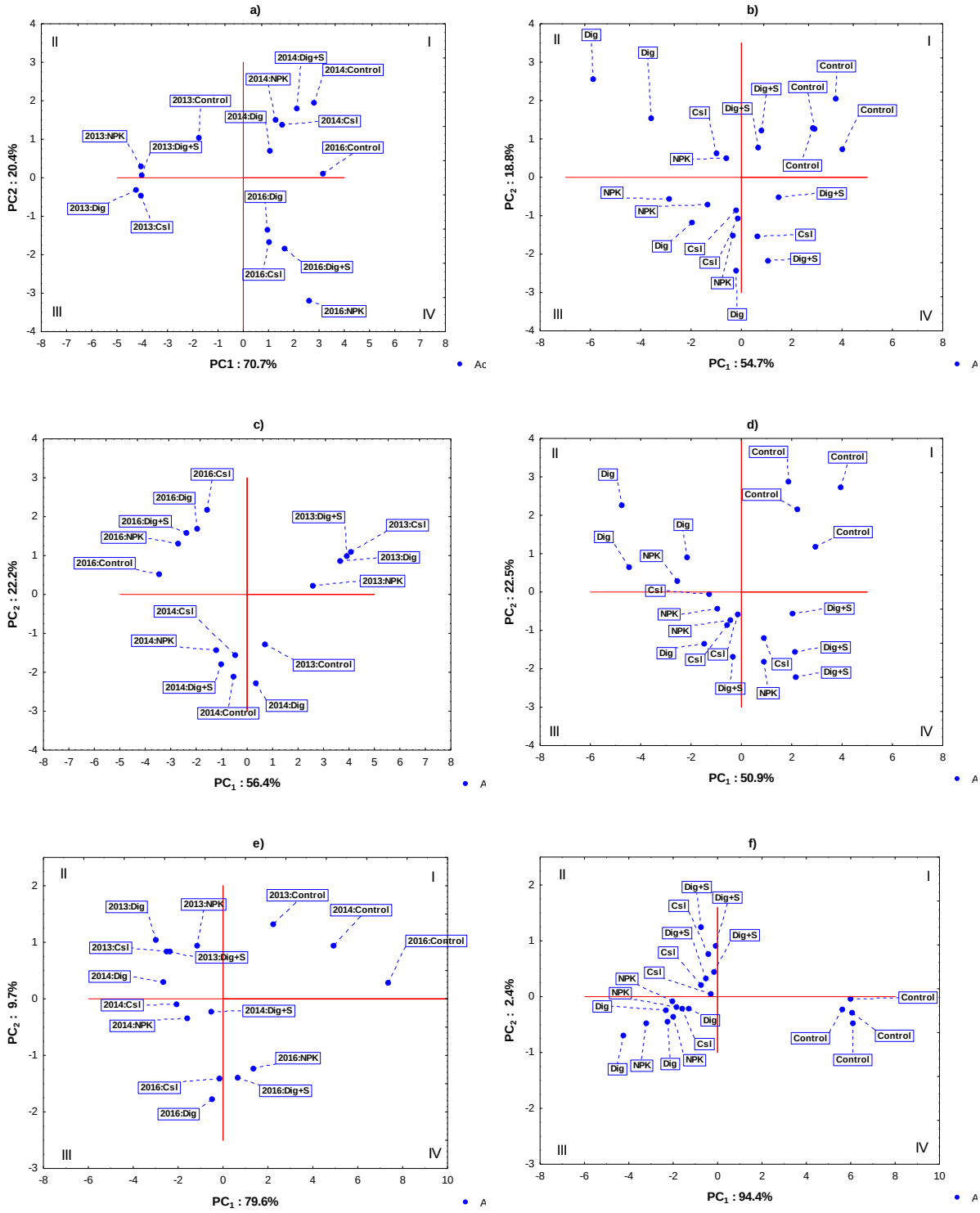

Figure S2. Projection of the cases (treatments) on the factor-plane for nutrient content in grain of winter wheat (a) and spring barley (b), nutrient content in straw of winter wheat (c) and spring barley (d), and for total nutrient uptake by of winter wheat (e) and spring barley (f). Treatments: Control – without fertilization, Dig – digestate, Dig+S – digestate + straw, Csl – cattle slurry, NPK – mineral fertilization.