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Supplement of

Soil nitrogen and water management by winter-killed catch crops

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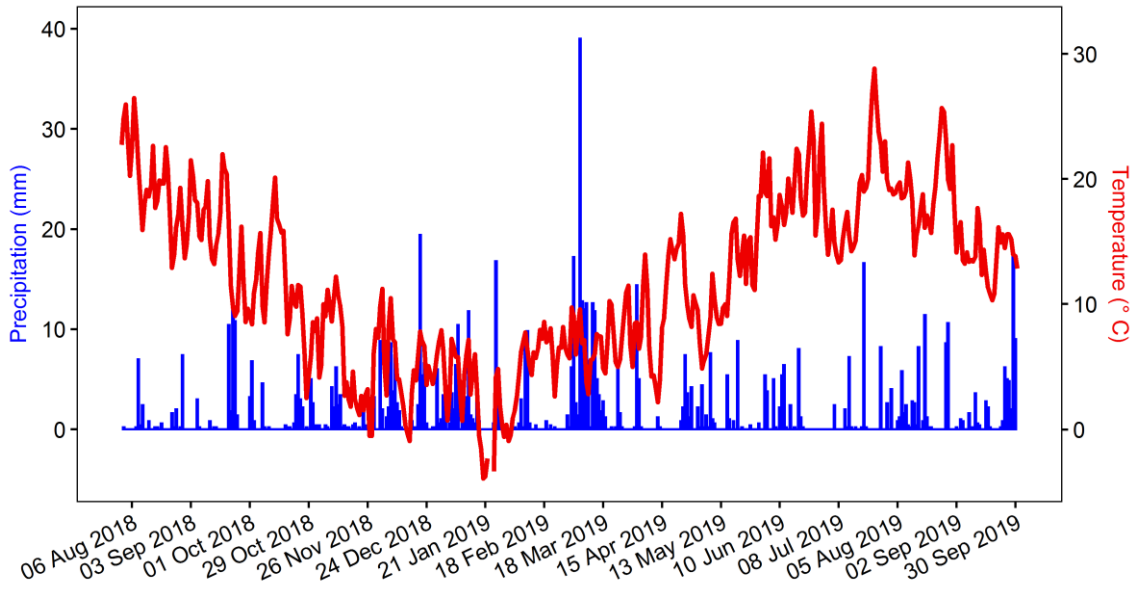

Figure S1: Temperature and precipitation during the soil monitoring period 2018/19. Date were recorded from a small weather station at the Asendorf field station.

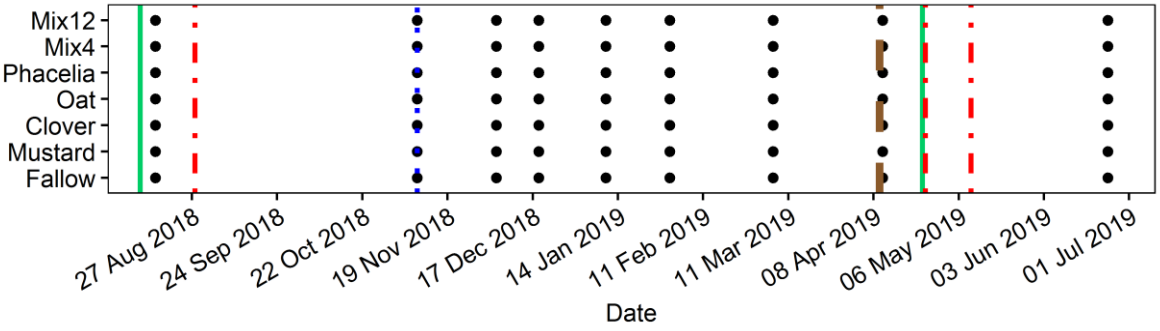

Figure S2: Timeline and treatments of the study. Black dots: soil sampling campaigns; green solid lines: seeding of catch crops and maize; blue dotted line: termination of catch crops; red dash dot lines; N fertilization according to Table S2; brown dashed line: seed bed preparation.

Table S1: Seeding density and proportion of seed in the field experiments.

Treatment	Catch crop	Plant common names	Plant scientific names	Cultivar	Proportion of seeds (% weight)	Proportion of seeds (% of seeds)	Seeding density (seeds m^{-2})	Seeding ammount (kg ha^{-1})
1	Bare fallow							
2	Mustard	White mustard	*Sinapis alba L.*	Litember	100.0	100.0	300.0	18.0
3	Clover	Egyptian clover	*Trifolium alexandrinum L.*	Alex	100.0	100.0	833.3	25.0
4	Oat	Bristle oat	*Avena strigosa Schreb.*	Panache	100.0	100.0	588.2	100.0
5	Phacelia	Phacelia	*Phacelia tanacetifolia Benth.*	Beehappy	100.0	100.0	705.9	12.0
6	Mix4	White mustard	*Sinapis alba L.*	Litember	16.0	10.3	66.7	
		Phacelia	*Phacelia tanacetifolia Benth.*	Beehappy	20.0	45.5	294.1	
		Egyptian clover	*Trifolium alexandrinum L.*	Alex	28.0	36.1	233.3	
		Bristle oat	*Avena strigosa Schreb.*	Panache	36.0	8.2	52.9	
	Total				100.0	100.0	647.1	25.0
7	Mix12	Field pea	*Pisum sativum L.*	Livioletta	38.0	1.0	7.2	
		Sorghum	*Sorghum bicolor L.*	Mithrill	14.0	2.6	19.6	
		Phacelia	*Phacelia tanacetifolia Benth*	Beehappy	7.0	18.8	131.0	
		Linseed	*Limum usitatissimum L.*	Lirina	8.0	6.5	41.4	
		Hungarian vetch	*Vicia pannonica Cranz.*	Beta	6.0	0.7	4.5	
		Deeptill radish	*Raphanus sativus L.*	Deeptill	5.0	1.1	10.2	
		Niger	*Guizotia abyssinica Cass.*		4.0	7.1	51.5	
		Sunflower	*Helianthus annuus L.*	Peredovick	2.0	0.1	1.2	
		False flax	*Camelina sativa L.*	Ligena	2.0	8.5	54.7	
		Persian clover	*Trifolium resupinatum L.*	Maral	4.0	15.1	92.7	
		Alsike clover	*Trifolium hybridum L.*	Aurora	5.0	29.5	224.4	
		Crimson clover	*Trifolium incarnatum L.*	Linkarus	5.0	9.0	50.3	
	Total				100.0	100.0	688.7	35.0

Table S2: Fertilization rates of catch crops and maize during the monitoring period 2018/19.

Crop	Application date	Fertilizer name	Elements	Amount (element base; kg ha^{-1})
Catch crop	28 August 2018	UAN28	N	47
Maize	19 Mart 2019	Granukal S	Mg/S	15/40
	24 April 2019	Diammonium Phosphate	N/P	22/55
	02 Mai 2019	Kornkali	K/Mg/S	100/15/13
	10 Mai 2019	UAN28 with S	N/S	80/17

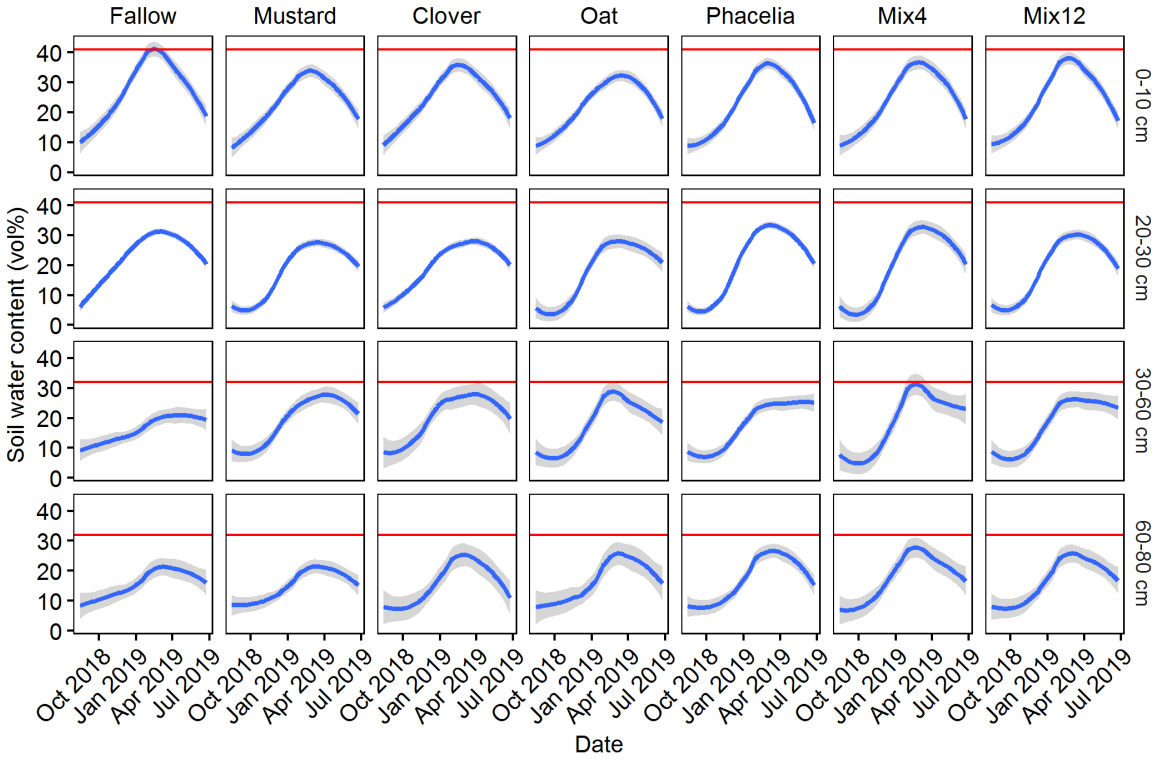

Fig. S3: Volumetric soil water content in different depth increments (vol%) throughout the observation period. The red horizontal line mark the field capacity (vol%) and the grey shade around the line displays confidence intervals.

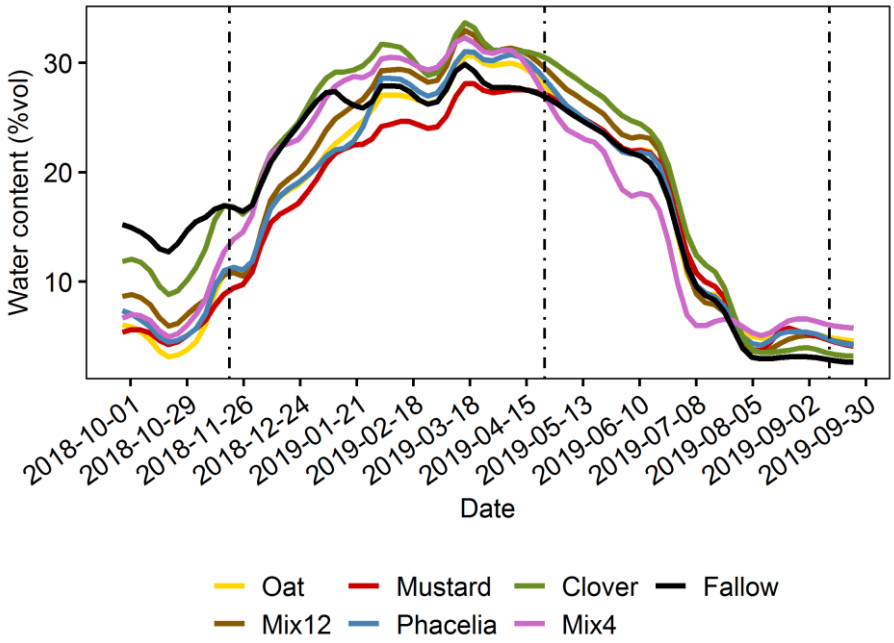

Fig. S4: Volumetric water content summarized from countinuouse data logging for one year in the upper 0-30 cm soil. Lines represent means of 2 to 3 replicates (except Mix4) and was smothed with a local polynomic regression model (loess span = 0.5). Vertical dashed lines mark different management events from left to the right: CC termination, maize seeding, and maize harvest. Data and R code are provided as supplement.

Table S3: Differences in total water content (L m^{-2}; summarized to 80 cm depth) between CC treatments. Pairwise comparison from Fig. 5 at the individual sampling dates. R codes and data are provided in Supplement 2. Small letter denote the contribution to statistic different groups.

Catch crop	15 Aug 2018	09 Nov 2018	05 Dec 2018	19 Dec 2018	10 Jan 2019	31 Jan 2019	06 Mar 2019	11 Apr 2019	24 Jun 2019
Fallow	a	c	b	ab	a	ac	b	a	ab
Mustard	a	a	a	a	a	a	ab	ab	ab
Clover	a	bc	b	b	ab	abc	ab	ab	ab
Oat	a	ab	ac	a	a	abc	ab	a	a
Phacelia	a	a	ac	ab	a	abc	a	b	b
Mix4	a	a	ac	a	b	b	ab	ab	ab
Mix12	a	a	c	a	ab	bc	ab	b	ab

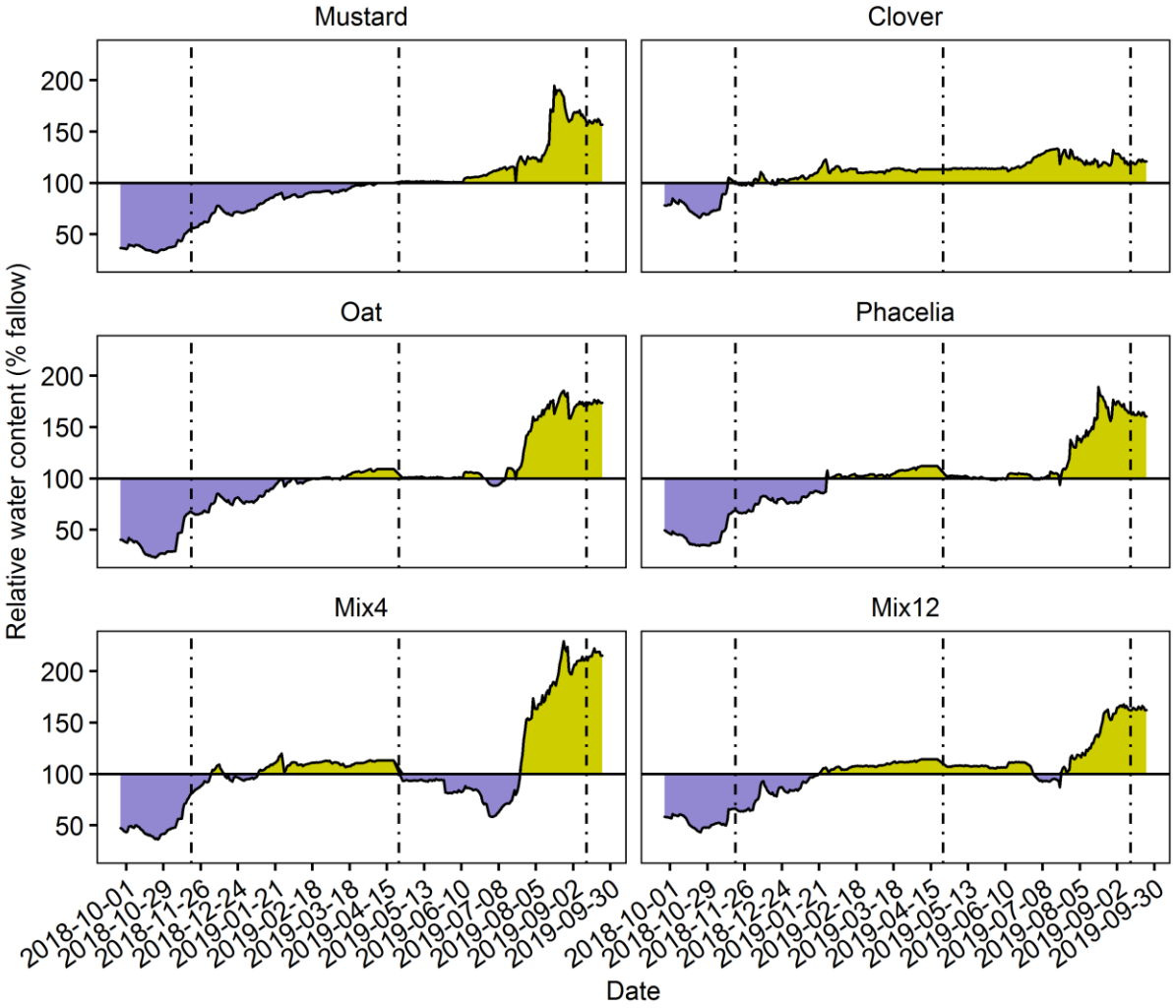

Fig. S5: Time course of soil water content from data loggers in the upper soil (0-30 cm) during the observation period. Values are presented relative to the fallow level (100%) with green areas for above fallow levels and blue ones for below fallow levels. Lines are mean values of 2 to 3 replicates. For Mix4 only one logger provided continuous results. In total we lost 6 loggers by wild animal damage. Vertical dashed lines marks different management events from left to the right: CC termination, maize seeding, and maize harvest. Data and R code are provided as supplement.

Table S4. C:N ratios of individual plant parts from different CC species. Data derived from a greenhouse experiment in 2018. Mean values of six to eight measurements and standard error (SE) are shown.

Plant	Leaf		Stalk		Root	
	Mean	SE	Mean	SE	Mean	SE
False flax	8.0	0.9	30.8	7.4	37.9	6.7
Egyptian clover	9.9	0.2	14.8	0.6	16.8	0.5
Linseed	8.6	0.7	19.1	2.4	29.3	3.7
White mustard	10.5	0.4	33.6	2.5	48.3	2.9
Bristle oat	15.2	0.4	34.0	1.5	3 +9.8	1.0
Field pea	14.2	0.5	34.2	0.5	26.2	2.8
Phacelia	8.8	0.3	19.7	1.8	27.7	2.0
Deeptill radish	10.5	1.1	n.a.	n.a.	18.6	2.2
Niger	8.7	0.2	11.9	0.2	34.7	0.1
Sorghum	18.8	2.1	38.1	7.8	55.6	3.4
Sunflower	12.7	0.1	78.9	0.3	48.0	0.0
Hungarian vetch	9.4	0.3	16.8	1.5	17.3	1.2

Fig. S5: Mustard shoot residues after the winter (March 2019).

Fig. S6. Oat residues after the winter (March 2019)

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Table S5 Monthly precipitation and temperature for the years 2018 and 2019 and long-term data for the period 1981 to 2010.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
	Precipitation sum (mm)												
2018	141	10	33	63	16	29	28	23	41	41	28	82	535
2019	81	25	159	41	35	41	40	63	59	117	66	53	780
1981-2010	69	52	58	43	56	67	73	71	64	63	65	70	751
	Average temperature (°C)												
2018	3.9	-0.9	2.8	12.1	16.7	17.6	20.4	19.6	15.5	11.3	5.7	5.2	10.8
2019	2.0	5.4	7.1	9.8	11.3	19.3	18.6	19.2	14.2	11.1	5.5	4.8	10.7
1981-2010	1.7	2	4.8	8.6	12.8	15.3	17.7	17.4	13.8	9.7	5.4	2.3	9.3