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 amount (kg ha\(^{-1}\)) |
|-----------|------------|--------------------|------------------------|----------|-------------------------------|----------------------------------|----------------------------------|----------------------------------|
| 1         | Bare fallow Mustard | White mustard | *Sinapis alba* L. | Litember | 100.0 | 100.0 | 300.0 | 18.0 |
| 2         | Clover Egyptian clover | Bristle oat | *Trifolium alexandrinum* L. | Alex | 100.0 | 100.0 | 833.3 | 25.0 |
| 3         | Oat Bristle oat | Phacelia | *Phacelia tanacetifolia* Benth. | Beehappy | 100.0 | 100.0 | 705.9 | 12.0 |
| 4         | Mix4 White mustard | Phacelia | *Sinapis alba* L. | Litember | 16.0 | 10.3 | 66.7 | 14.1 |
|           | Phacelia Egyptian clover | Trifolium | *Trifolium alexandrinum* L. | Alex | 20.0 | 12.0 | 131.0 | 29.4 |
|           | Bristle oat | Phacelia | *Avena strigosa* Schreb. | Panache | 36.0 | 8.2 | 52.9 | 12.0 |
|           | Mix12 Field pea | Sorghum | *Pisum sativum* L. | Livioletta | 38.0 | 1.0 | 7.2 | 15.0 |
|           | Phacelia | Sorghum bicolor L. | *Sorghum bicolor* L. | Mithril | 14.0 | 2.6 | 19.6 | 4.8 |
|           | Phacelia | *Phacelia tanacetifolia* Benth. | *Phacelia tanacetifolia* Benth. | Beehappy | 7.0 | 18.8 | 131.0 | 33.0 |
|           | Linseed Hungarian vetch | Linseed | *Vicia pannonica* Cranz. | Beta | 6.0 | 0.7 | 4.5 | 1.2 |
|           | Deepill radish | Deepill | *Raphanus sativus* L. | Deeptill | 5.0 | 1.1 | 10.2 | 2.5 |
|           | Niger | Linseed | *Guizotia abyssinica* Cass. | Peredovich | 2.0 | 0.1 | 1.2 | 0.3 |
|           | Sunflower False flax | False flax | *Helianthus annuus* L. | Peredovich | 2.0 | 0.1 | 1.2 | 0.3 |
|           | False flax Persian clover | Persian clover | *Camelina sativa* L. | Ligena | 2.0 | 8.5 | 54.7 | 14.4 |
|           | False flax Crimson clover | Crimson clover | *Trifolium resupinatum* L. | Maral | 4.0 | 15.1 | 92.7 | 25.0 |
|           | False flax Crimson clover | Crimson clover | *Trifolium hybridum* L. | Aurora | 5.0 | 29.5 | 224.4 | 60.0 |
|           | False flax Crimson clover | Crimson clover | *Trifolium incarnatum* L. | Linkarus | 5.0 | 9.0 | 50.3 | 13.0 |
|           | Total | Total | Total | 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      | N/P      | 22/55                                |
|                 |                  | Phosphate       |          |                                      |
|                 | 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 continuous data logging for one year in the upper 0-30 cm soil. Lines represent means of 2 to 3 replicates (except Mix4) and was smoothed with a local polynomial 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          | a           | a           | abc         | a           | b           | b           |
| Mix4       | a           | a           | ac          | a           | b           | b           | ab          | ab          | ab          |
| Mix12      | a           | a           | c           | a           | a           | 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 | SE | Stalk | SE | Root | 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    | 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).
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 |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 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    |

Precipitation sum (mm)

| Year     | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 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    |

Average temperature (°C)