

## Supplementary materials

### Structural parameters

#### *Foliar nitrogen content*

To calculate foliar nitrogen, Kjeldahl's formula [1] was used, which relates SPAD and nitrogen, described by Eq. (S1):

$$HL\ Y= 0,274\ X +7,777 \quad (S1)$$

Here, the following pertains:

Y is SPAD unit data;

X is nitrogen.

From this formula, the measurement of leaf nitrogen was then derived, according to Eq. (S2):

$$N=((SPAD - 7,777))/0,274=\text{mmol/m} \quad (S2)$$

#### *Weight of fresh and dry biomass*

For each sample, the fresh biomass weight of roots, leaves, stems, and ears was determined using an analytical balance. Subsequently, the samples were dried in an oven at 105 °C for 24 hours to determine the total dry weight of each plant organ. The fresh and dry weights of the flag, median, and basal leaves were also measured for each sample in order to determine the specific leaf area. The dry weight of the flag, median, and apical leaves was calculated using Eqs. (S3), (S4) and (S5):

$$\begin{aligned} \text{Dry weight of flag leaf} &= \text{fresh weight of leaf (flag leaf)} * \\ &\text{average \% of moisture in total leaves of the plants} - 100 \end{aligned} \quad (S3)$$

$$\begin{aligned} \text{Dry weight of median leaf} &= \text{fresh weight of leaf (median)} * \\ &\text{average \% of moisture in total leaves of the plants} - 100 \end{aligned} \quad (S4)$$

$$\begin{aligned} \text{Dry weight of basal leaf} &= \text{fresh weight of leaf (basal)} * \\ &\text{average \% of moisture in total leaves of the plants} - 100 \end{aligned} \quad (S5)$$

#### *Moisture content*

The average % moisture content of all plant leaves was calculated using Eq. (S6),

$$\% \text{ moisture} = \left[ \frac{((\text{fresh weight of total leaves} - \text{dry weight of total leaves}))}{\text{fresh weight of total leaves}} \right] * 100 \quad (S6)$$

### *Straw weight*

The straw weight was calculated for each sample (Eq. (S7)), and is the sum of the dry weight of stems, leaves and ears, excluding roots.

$$\text{Straw weight} = (\text{dry weight of stems} + \text{dry weight of leaves} + \text{dry weight of ears}) \quad (\text{S7})$$

### *Height of stems and number of ears*

The heights of the stems (in cm) and the numbers of ears for each sample were measured.

### *Water content*

The percentage of humidity represents the moisture lost in the samples after the drying process in the oven, and was calculated using Eq. (S8) for each part of the plant—roots, stems, leaves, and spikes.

$$\% \text{ humidity} = \left[ \frac{(\text{fresh weight} - \text{dry weight})}{\text{fresh weight}} \right] * 100 \quad (\text{S8})$$

### *Leaf, roots, stems and ears partition coefficient*

The leaf partitioning coefficient was determined for each plant by calculating the ratio of the dry weight (in g) of the leaves to the total dry weight of the plant (in g), which includes all plant organs—roots, stems, leaves, and spikes, as shown in Eq. (S9). The leaf partitioning coefficient indicates how much of the plant's biomass is allocated to the leaves. The partitioning coefficients for roots, stems, and spikes were calculated in the same way as for the leaves (see Equations (S10), (S11), and (S12)).

$$\text{Coeff. leaf} = \text{dry weight of leaves} - \text{total dry weight} \quad (\text{S9})$$

$$\text{Coeff. roots} = \text{dry weight of roots} - \text{total dry weight} \quad (\text{S10})$$

$$\text{Coeff. stems} = \text{dry weight of stems} - \text{total dry weight} \quad (\text{S11})$$

$$\text{Coeff. ears} = \text{dry weight of ears} - \text{total dry weight} \quad (\text{S12})$$

### *Leaf Area*

For each sample, the leaf area (in cm<sup>2</sup>) of the flag, median, and basal leaves of each plant was measured by calculating the product of the length and width of the leaf and multiplying it by the radiation extinction coefficient (k), which for wheat is 0.75 (Eq. (S13)).

$$\text{Leaf area} = (\text{width} * \text{lenght}) * 0.75 \quad (\text{S13})$$

### *Specific leaf area (SLA)*

The Specific Leaf Area (SLA) is defined as the ratio of the leaf blade area to its corresponding dry weight, expressed in  $\text{m}^2/\text{kg}^{-1}$  (Equation (S12)). For example—leaf area of the flag leaf / dry weight of the flag leaf. SLA responds not only to light, but also to stress factors present in the environment (e.g., water stress).

$$SLA = \text{leaf dry weight} \quad (\text{S14})$$

### *Leaf Area Index (LAI)*

The Leaf Area Index (LAI) is a biometric parameter defined as the total leaf area ( $\text{m}^2$ ) that intercepts light energy, expressed in relation to the underlying ground area ( $\text{m}^2$ ). To determine the LAI, the sum of the leaf area of the three leaves (flag, median, and basal) for each plant was calculated, converted to  $\text{m}^2$ , and multiplied by the plant density (plants/ $\text{m}^2$ ), which is 157 plants/ $\text{m}^2$  for the conventional field and 140 plants/ $\text{m}^2$  for the agroecological plot. The LAI can take on highly variable values, typically ranging from 2 to 6, and depends on various factors, including species composition, developmental stage, site conditions, season, management methods, and more.

## **Production parameters**

### *Harvest Index*

The harvest index was calculated using Eq. (S15):

$$\text{Harvest index (\%)} = \text{grain weight ((g))} / \text{strow weight (g)} \quad (\text{S15})$$

### *Seed Yield*

Seed yield was calculated using Eq. (S16):

$$\text{Seed yield (t/ha)} = \text{seed weight/soil area (m}^2\text{)} \quad (\text{S16})$$

### *Aridity Index*

The aridity classes defined by the De Martonne index are those shown in Table S1. This index, in addition to being used in climatology, is also utilized in agronomy, as it can specify the different degrees of humidity, and thus can express the extreme environmental conditions of plants or certain crops with numerical values.

**Table S1:** Aridity classes defined by the De Martonne index.

Aridity Index	Climatic type
0-5	Extreme arid (desert)
5-15	Arid (steppes and circum-deserts)
15-20	Semi-arid (Mediterranean type)
20-30	Sub-humid
30-60	Humid
> 60	Hyper-humid

$$IA = \frac{P}{(10+T)} \quad (S17)$$

Here, the following pertains:

IA is the aridity index;

P is the average annual rainfall (mm);

T is the mean annual temperature (°C).

### Results of structural and production parameters of plants

**Table S2:** Group descriptives of chlorophyll content, leaf nitrogen content, structural parameters of the field, and productivity parameters in the two treatments, AE = agroecological and CP = conventional. 1b, 2m, and 3b refer, respectively, to the flag leaf, median leaf, and basal leaf on which chlorophyll and leaf nitrogen content were measured for each plant sample.

	Treatment	N	Mean	SD	SE
SPAD_ leaves 1b-2m-3b (unit SPAD)	AE	90	49.8	5.45	0.575
	CP	90	45.4	5.43	0.572
Leaf nitrogen 1b-2m-3b (mmol/m <sup>2</sup> )	AE	90	153	19.9	2.10
	CP	90	137	19.8	2.09
total dry weight (g)	AE	90	15.7	4.95	0.522
	CP	90	26.7	13.31	1.403
Roots dry weight (g)	AE	90	3.30	1.34	0.142
	CP	90	4.24	2.25	0.237
Stems dry weight (g)	AE	90	5.47	1.77	0.186
	CP	90	6.69	2.63	0.278
Total moisture (%)	AE	90	44.8	4.76	0.502

	CP	90	46.4	4.15	0.438
Moisture stems (%)	AE	90	55.7	5.96	0.628
	CP	90	57.8	6.16	0.649
Moisture leaves (%)	AE	90	29.6	10.50	1.107
	CP	90	34.2	8.95	0.943
Stems height (cm)	AE	90	67.1	8.66	0.913
	CP	90	62.6	5.02	0.529
Number of ears	AE	90	5.97	1.55	0.163
	CP	90	6.73	1.92	0.203
Leaves partition coefficient (%)	AE	90	0.168	0.0335	0.00354
	CP	90	0.137	0.0304	0.00320
Ears partition coefficient (%)	AE	90	0.271	0.0611	0.00644
	CP	90	0.265	0.0638	0.00673
Roots partition coefficient (%)	AE	90	0.212	0.0669	0.00705
	CP	90	0.230	0.0754	0.00795
Stems partition coefficient (%)	AE	90	0.350	0.0493	0.00520
	CP	90	0.368	0.0448	0.00472
Leaf area (cm <sup>2</sup> )	AE	90	12.8	5.27	0.555
	CP	90	14.6	7.09	0.747
Leaf Area Index (LAI)	AE	90	0.537	0.125	0.0132
	CP	90	0.688	0.179	0.0189
Specific Leaf Area (m <sup>2</sup> /kg <sup>-1</sup> )	AE	90	31.3	5.80	1.06
	CP	90	36.5	8.20	1.50
Harvest Index (%)	AE	90	0.355	0.128	0.0135
	CP	90	0.326	0.126	0.0133
Seed yield (t/ha)	AE	10	2.36	0.609	0.192
	CP	10	2.07	0.532	0.168

## Results of soil analysis

**Table S3.** Group descriptives for exchangeable calcium (ppm) and cation exchange capacity (meq/100 g) in the two treatments, AE = agroecological and CP = conventional, before wheat sowing, from soil samples collected in October 2019.

	Treatment	N	Mean	SD	SE
Exchange calcium (ppm)	AE1	10	6044	316	100.0
	CP1	10	5660	374	118.2
CSC (meq/100 g)	AE1	10	32.7	1.67	0.528
	CP1	10	30.9	1.85	0.587

**Table S4.** Group descriptives for exchangeable calcium (ppm) and cation exchange capacity (meq/100 g) in the two treatments, AE harvest = agroecological and CP harvest = conventional, after wheat harvest.

	Treatment	N	Mean	SD	SE
Calcio di scambio (ppm)	AE harvest	10	5030	226	71.6
	CP harvest	10	4690	280	88.6
CSC (meq/ 100 g)	AE harvest	10	27.8	1.17	0.368
	CPharvest	10	26.1	1.36	0.431

## References

- [1] XIONG, Dongliang, et al. SPAD-based leaf nitrogen estimation is impacted by environmental factors and crop leaf characteristics. Scientific reports, 2015, 5.1: 13389.