

Supplementary Material

Table S1. Soil chemical characteristics at different depths.

Depth	NH ₄ ⁺	NO ₃ ⁻	Total N	pH	Organic matter	Phosphorus
(cm)	(ppm)	(ppm)	(%)		(%)	(ppm)
0-15	14.00	10.18	0.46	7.63	3.8	2.57
15-30	16.74	7.64	0.35	7.54	2.2	4.00
0-30	15.37	8.91	0.41	7.58	3.0	3.29

Table S2. Monthly total accumulated rainfall (PP), minimum air temperature (T min), maximum air temperature (T max) and average air temperature (T aver) for the 2014-2015 crop season. Values were collected at the meteorological station of Khemis Miliana (Algeria).

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
PP (mm)	25.1	14.8	59.4	120.4	62.2	107.8	42.5	0	8.8	10.1
T min (°C)	20.8	16	11.6	5.3	4	5.2	6.4	12.7	15	16.98
T max (°C)	34	29.1	18.2	13.2	12.5	10.1	17	25.4	28.2	30.23
T aver (°C)	27.4	22.55	14.9	9.25	8.25	7.65	11.7	19.1	21.58	23.6

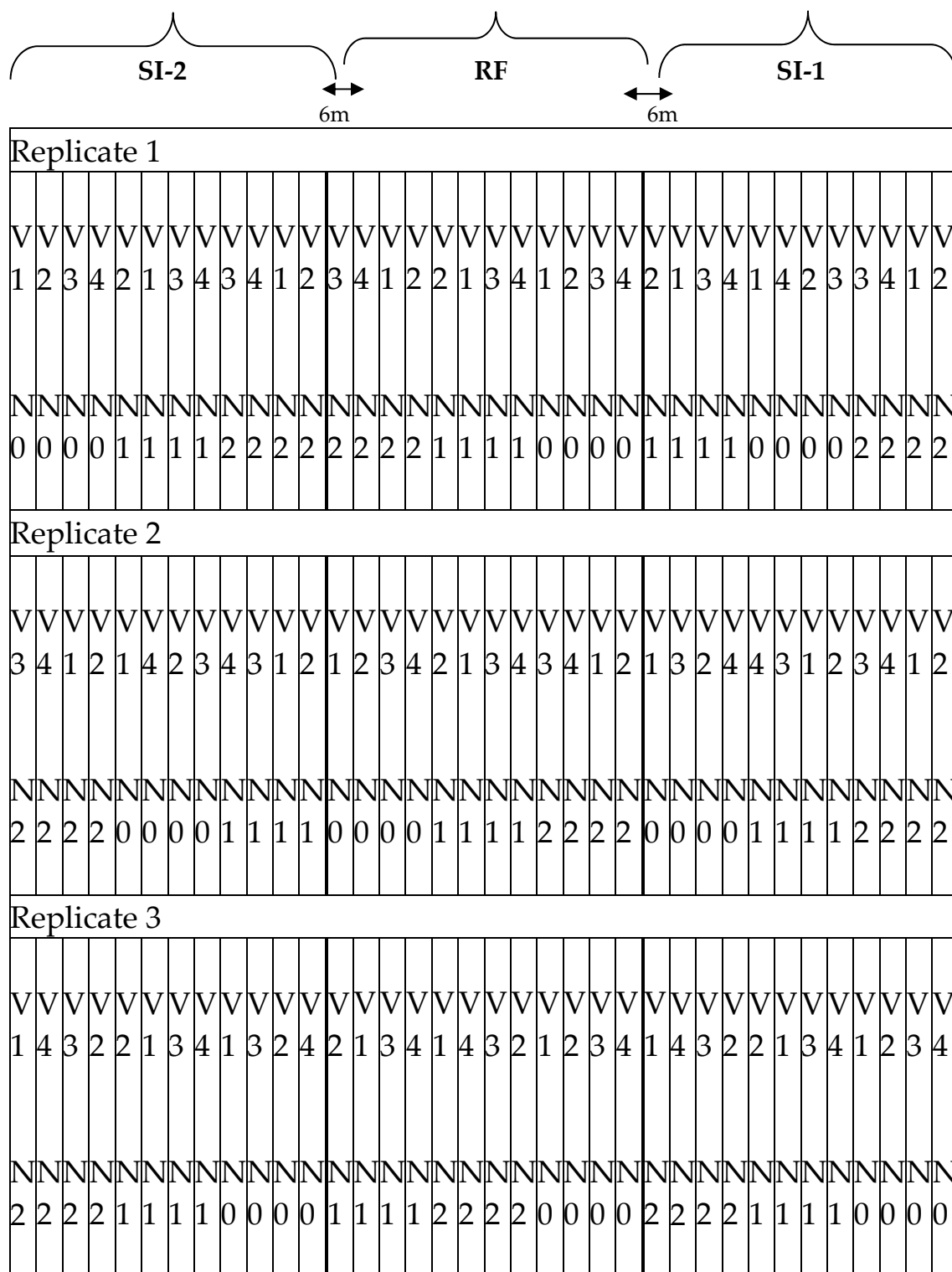
Table S3. Correlation coefficients of the linear relationships of grain yield (GY) with NDVI, GA, GGA, CTD and $\delta^{13}\text{C}$ under irrigation without N fertilization and rainfed conditions with N120, N60 and without N.

	Irrigation without N	Rainfed with N120	Rainfed with N60	Rainfed without N
GY with NDVI	-0.19 ^{ns}	0.37 ^{ns}	/	-0.09 ^{ns}
GY with GA	-0.04 ^{ns}	0.30 ^{ns}	/	-0.23 ^{ns}
GY with GGA	-0.20 ^{ns}	0.12 ^{ns}	/	-0.36 ^{ns}
GY with CTD	-0.02 ^{ns}	/	0.24 ^{ns}	0.18 ^{ns}
GY with $\delta^{13}\text{C}$	-0.35 ^{ns}	/	0.06 ^{ns}	0.16 ^{ns}

GY, grain yield; NDVI, Normalized Difference Vegetation Index; GA, Green Area; GGA, the Greener Area; CTD, the canopy temperature depression; $\delta^{13}\text{C}$, the stable carbon isotope composition of the mature grains and the grain yield (GY). Nitrogen fertilization N60 and N120, refer to 60 kg ha⁻¹ and 120 kg ha⁻¹ of nitrogen fertilization, respectively Significance levels—ns, not significant

Table S4. Multiple linear regressions (stepwise) across genotypes and replicates explaining grain yield (GY) variation as a dependent variable and the NDVI, GA, GGA, LC, CTD, the stomatal conductance (g_s) and $\delta^{13}C$ as independent variables. Data were analyzed within each level of nitrogen fertilization and water regime. Significance levels—* $P < 0.05$; ** $P < 0.01$ and *** $P < 0.001$. Abbreviations for variables and growing conditions as defined in Tables 1 and 2.

Dependent Variable	Growing condition	Variable chosen	R	Final stepwise model
GY	SI-2 with N120	No variables were entered into the equation for this treatment		
GY	SI-2 with N60	$\delta^{13}C$	0.58*	$-7.32 - 0.40 \delta^{13}C$
GY	SI-2 without N	GA	0.66**	$4.79 - 2.84 GA$
GY	SI-1 with N120	No variables were entered into the equation for this treatment		
GY	SI-1 with N60	No variables were entered into the equation for this treatment		
GY	SI-1 without N	No variables were entered into the equation for this treatment		
GY	Rainfed with N120	CTD	0.66***	$2.27 + 0.09 CTD-IT$
GY	Rainfed with N60	NDVI	0.63**	$0.80 + 2.33 NDVI$
GY	Rainfed without N	No variables were entered into the equation for this treatment		



V1, Ain-Abid; V2, Arz; V3, Maaouna; V4, Wifak. Nitrogen fertilization: N0, N1 and N2, refer to absence, 60 kg ha⁻¹, and 120 kg ha⁻¹ of nitrogen fertilization, respectively. Water regime: RF, SI-1 and SI-2 refer to rainfed conditions and 30 mm and 60 mm of water for support irrigation, respectively

Figure S1. Scheme detailing the different plots of the experimental design.

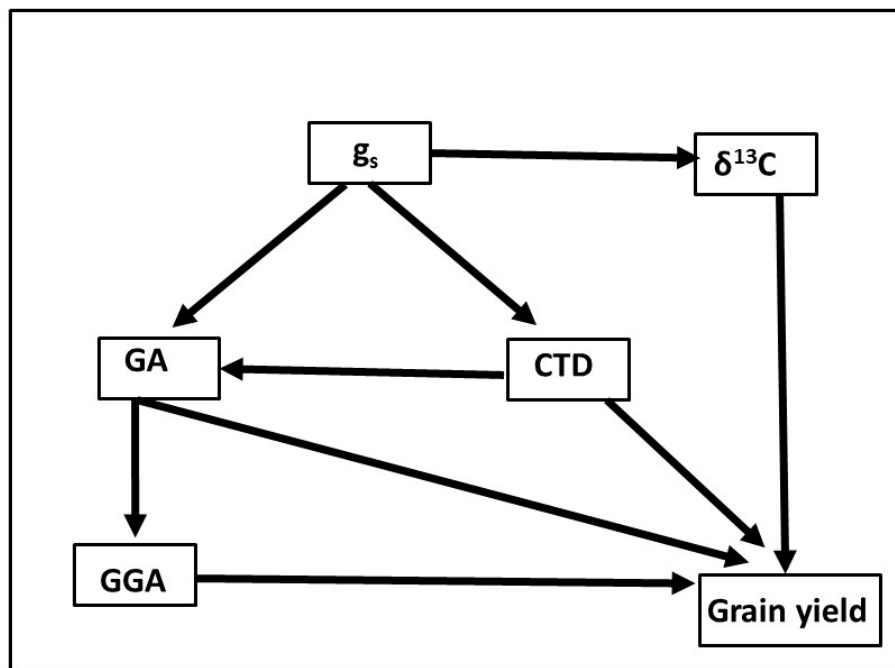


Figure S2. Conceptual model of the path analyses quantifying the relative strengths of the direct and indirect relationships of the different physiological traits and grain yield. Physiological parameters included in the model are: The g_s , the $\delta^{13}C$ of mature grains, the GA and the GGA indices calculated from digital pictures, and the CTD measured with an infrared thermometer.

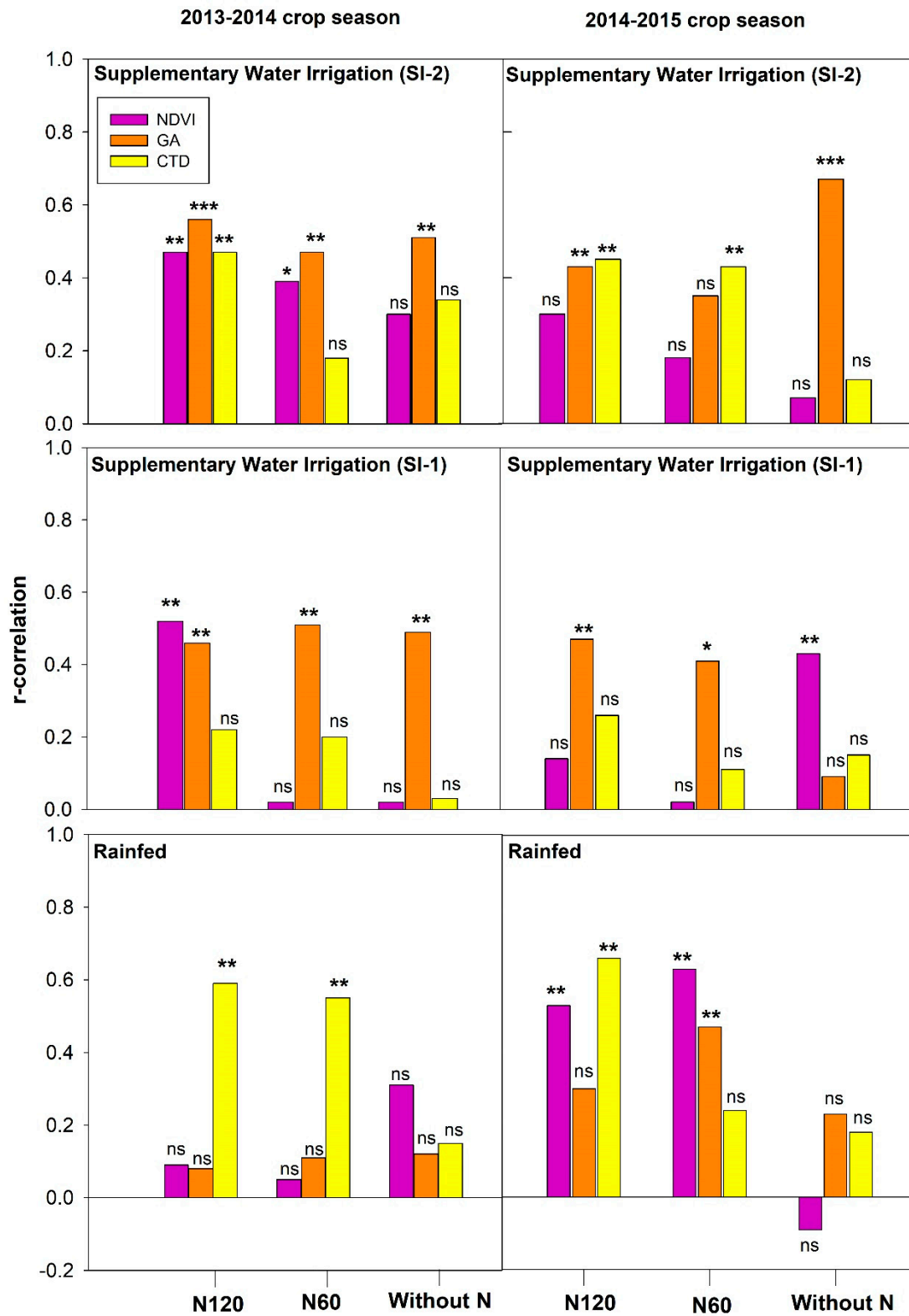
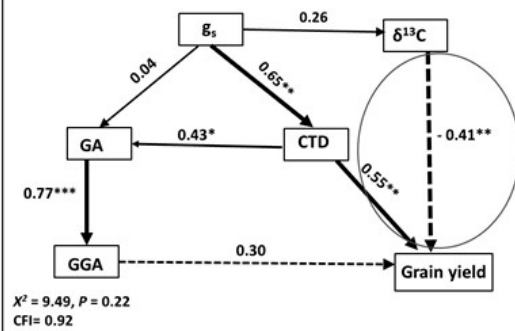
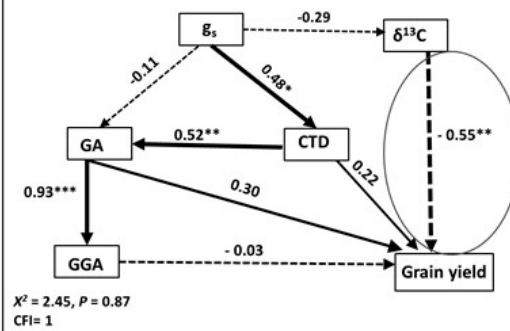


Figure S3. Relationships of the measured versus the predicted grain yields of wheat achieved during two successive crop seasons (2013-2014 and 2014-2015). Predicted grain yield values were calculated using the linear relationships of the grain yield with the two vegetation indices, the NDVI measured with a portable spectroradiometer, and the relative GA index calculated from digital images, and the CTD measured with an infrared thermometer. All variables were evaluated during the 2012-2013 crop season. Measurements were performed in the same region as the present study. Grain yield and vegetation index data of the two first crop seasons have been reported in Yousfi et al. (2016). For each crop season, the nine different growing conditions (resulting from the combination of the three water regimes and the three nitrogen fertilization levels) were analysed. The different combinations of nitrogen fertilization and water regimes for the 2013-2014 crop season were as follows: Supplementary irrigation (SI-2) with nitrogen fertilization N120 and N60 and without N fertilization; Supplementary irrigation (SI-1) with nitrogen fertilization N120 and N60 and without N fertilization; Rainfed with nitrogen fertilization N120 and N60 and without N fertilization. In addition, for the 2014-2015 crop season the combinations were as follows: Supplementary irrigation (SI-2) with nitrogen fertilization N120 and N60 and without N fertilization; Supplementary irrigation (SI-1) with nitrogen fertilization N120 and N60 and without N fertilization; Rainfed with nitrogen fertilization N120 and N60 and without N fertilization. Significance levels—ns, not significant; *P < 0.05; **P < 0.01 and ***P < 0.001.

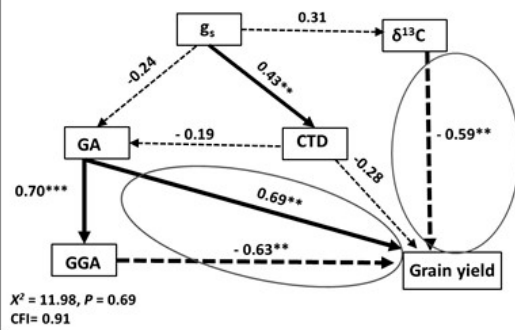
(A) SI-2 with N120



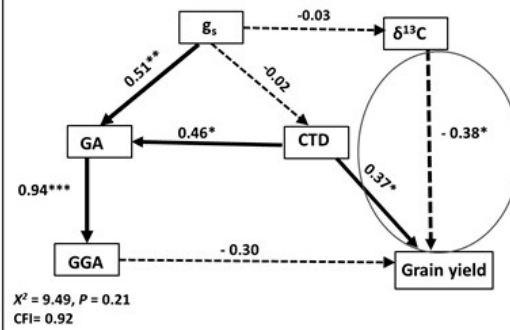
(B) SI-2 with 60



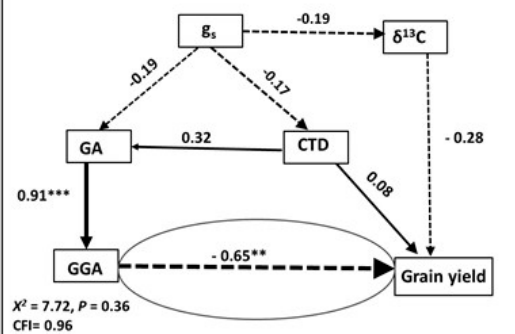
(C) SI-2 without N fertilization



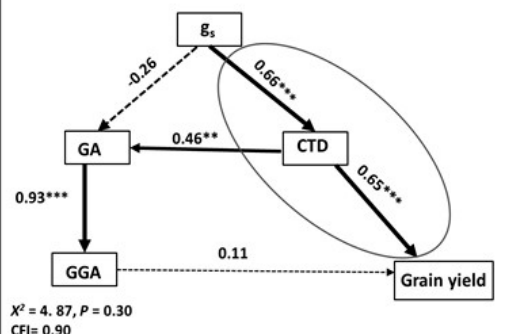
(D) SI-1 with N120



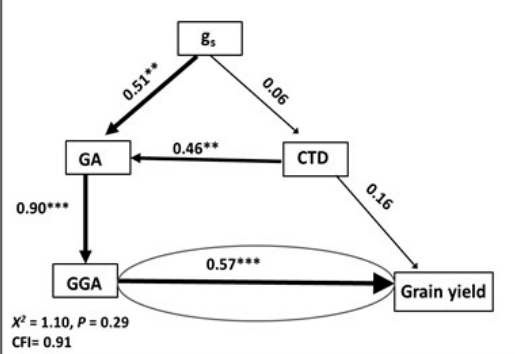
(E) SI-1 without N fertilization



(F) Rainfed with N120



(G) Rainfed with N60



(H) Rainfed without N fertilization

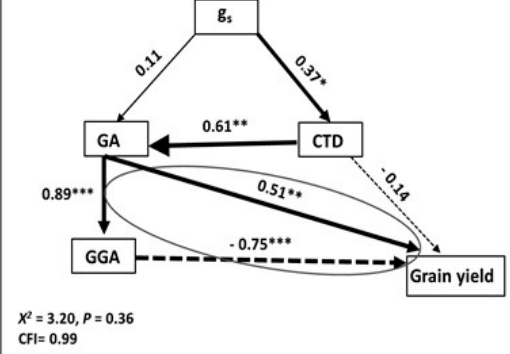


Figure S4. Path analyses of four wheat genotypes grown under different combinations of nitrogen fertilization and water regimes. The different combinations of nitrogen fertilization and water regimes are as follows: **(A)** SI-2 with high fertilization (N120); **(B)** SI-2 with medium nitrogen fertilization (N60); **(C)** SI-2 without nitrogen fertilization; **(D)** SI-I with high nitrogen fertilization (N120); **(E)** SI-I without nitrogen fertilization (N60); **(F)** Rainfed with high fertilization (N120); **(G)** Rainfed with medium nitrogen fertilization (N60); **(H)** Rainfed without nitrogen fertilization. Physiological parameters included in the model are: The g_s , the $\delta^{13}C$ of mature grains, the GA and the GGA indices calculated from digital pictures, and the CTD measured with an infrared thermometer. The width of the arrows is proportional to the path coefficient values. Dashed lines indicate negative relationships. Overall fit statistics for each path model (chi-squared, the probability and comparative fit index, CFI) are shown at the bottom left of each panel. CFIs with values > 0.9 were taken as indicative of a good fit. Significance levels—*P < 0.05; **P < 0.01 and ***P < 0.001.