

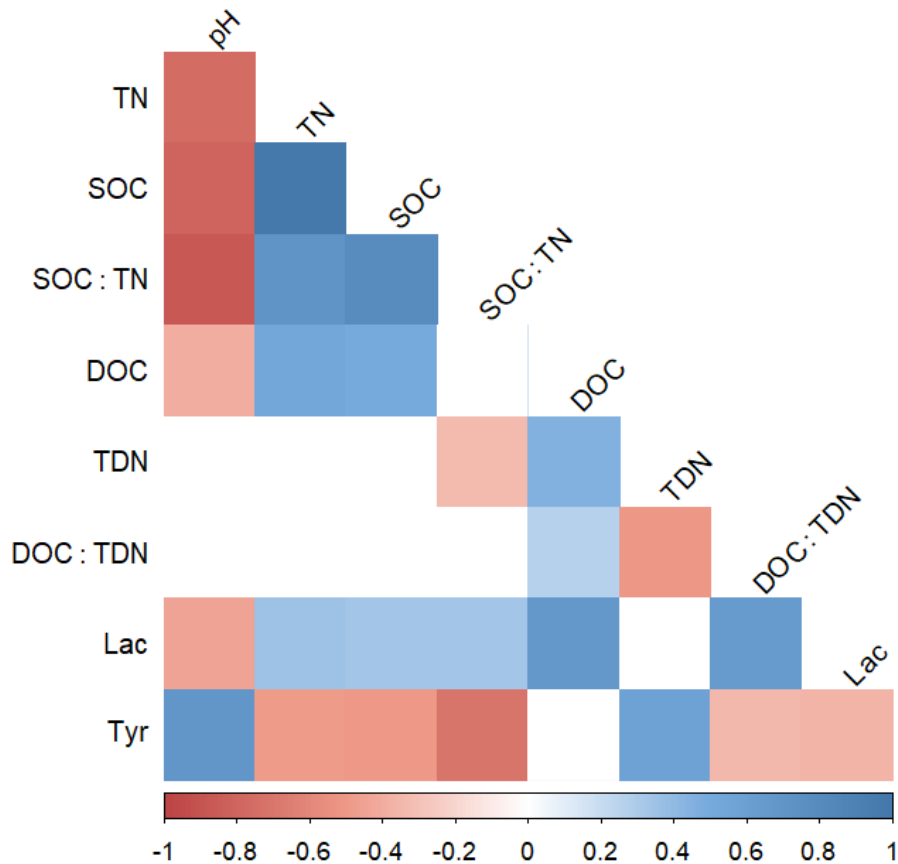


Figure 1. Correlation plot including the soil pH, available C and N (DOC and TDN) and their ratio (DOC:TDN), total C and N (SOC and TN) and their ratio (SOC:TN), tyrosinase activity (Tyr), laccase activity (Lac). Positive (blue) and negative (red) correlation plotted have p-value < 0.05.

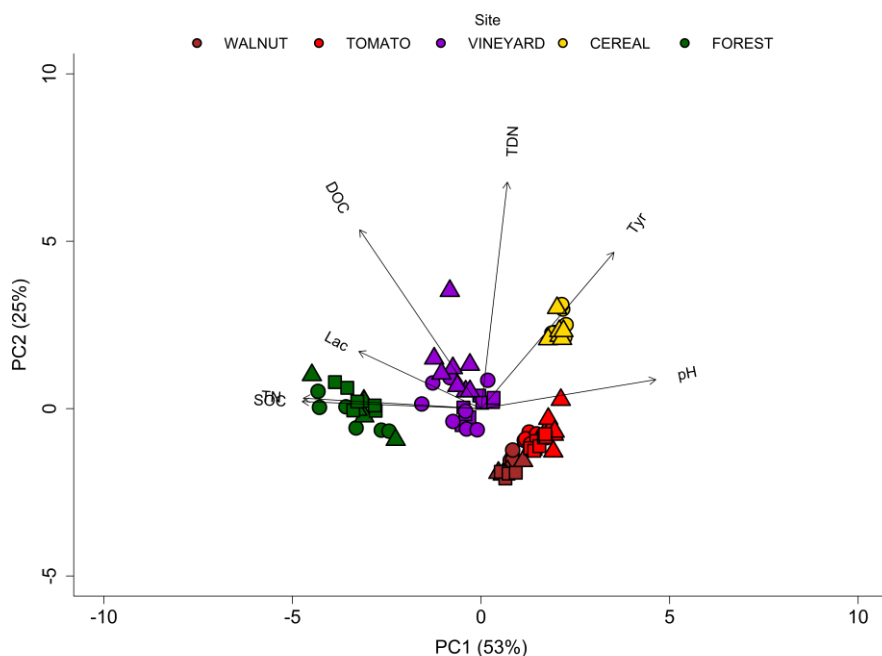


Figure 2. Principal Component Analysis (PCA) plot including the soil pH, available C and N (DOC and TDN), total C and N (SOC and TN), tyrosinase activity (tyr) and laccase activity (lac).

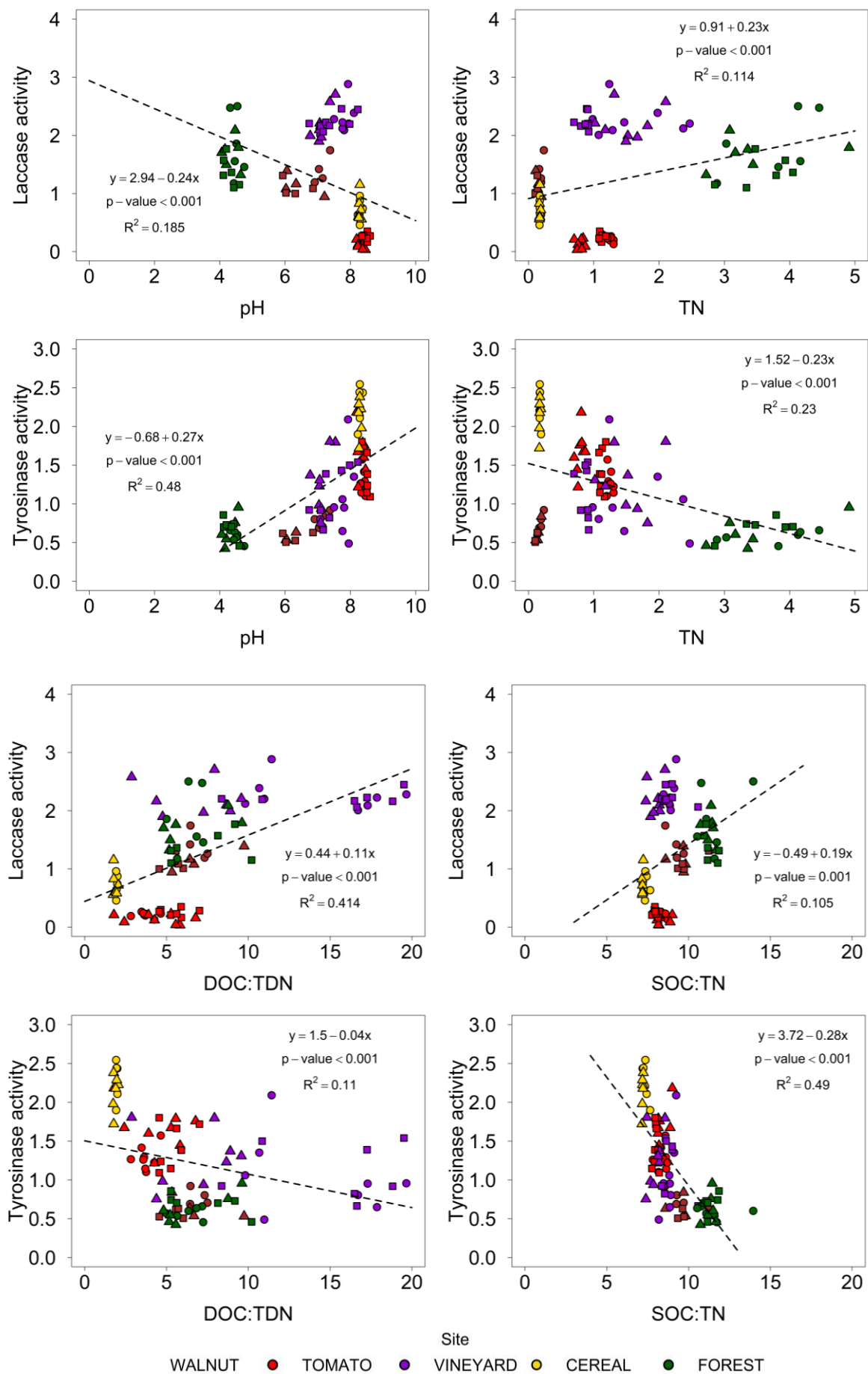


Figure 3. Linear regression plot including the two oxidative enzymatic activities (Laccase and Tyrosinase) in relation with soil pH, Total Nitrogen (TN), the ratio of available C and N (DOC:TDN), and the ratio of soil total C and N (SOC:TN). In each plot, the equation of the curve, its R square (R^2) and the associated p-value are reported.

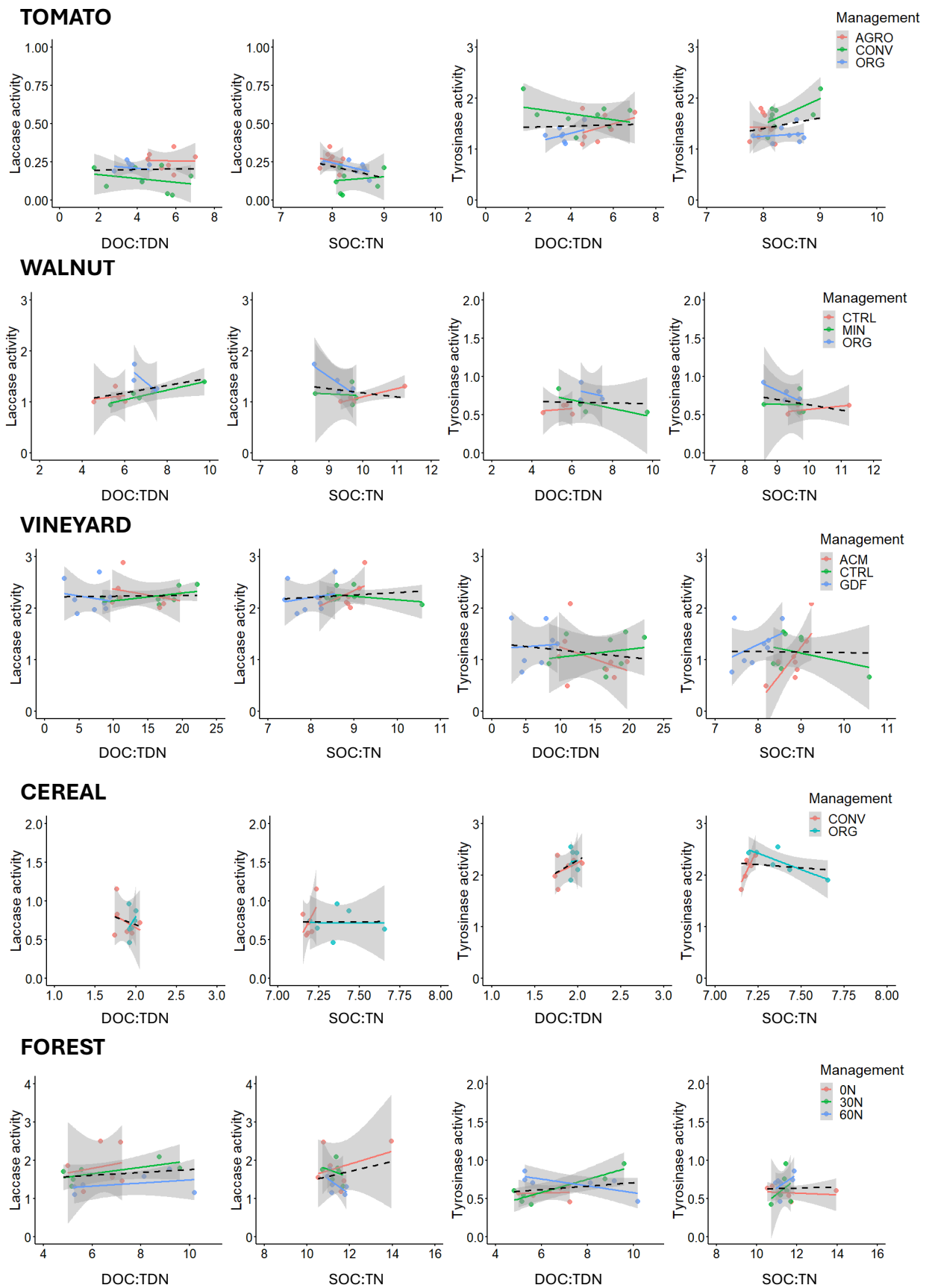


Figure 4. Linear regression plot for each experimental site including the two oxidative enzymatic activities (Laccase and Tyrosinase) in relation with the ratio of available C and N (DOC:TDN), and the ratio of soil total C and N (SOC:TN). Black dashed line refers to the regression within the site, coloured lines are indicative of only the inter-site comparison and refer to the regression within each site management.

Table 1. Site characterization with type of cultivation, soil classification and generale properties, organic and conventional management details.

Site	Cultivation & soil characterization	Managements
WALNUT	<i>Juglans regia</i> L., cultivar ‘Lara’. Orchard floor was not tilled, maintained permanently with a mix of grass species mown twice a year. Fine-silty, mixed soil. Udifluventic Haplustepts (USDA Soil Taxonomy). Sub-acid pH (6.8), with low content of active lime ($< 30 \text{ g kg}^{-1}$), organic matter (11 g kg^{-1}), and total N (1 g g^{-1}).	CTRL: Untreated control MIN: Commercial urea (46% N) applied to reach the N rate of $100 \text{ kg ha}^{-1} \text{ yr}^{-1}$, with total N rate split yearly between the flowering (60%) and postharvest (40%) periods. ORG: Compost from a mix of organic municipal wastes, pruning material from urban ornamental trees and gardens, and agro-industrial organic residues. Compost was distributed to reach the N rate of $100 \text{ kg ha}^{-1} \text{ yr}^{-1}$, applied to the soil surface without tilling.
TOMATO	Tomatoes (<i>Solanum lycopersicum</i> L.) . The soil is classified as Typic Calcixerepts fine-loamy, mixed thermic (USDA Soil Taxonomy, 2006).	CONV: Plowing (0.4 m), harrowing (0.3–0.4 m). Synthetic and mineral NPK fertilizers: Nitrofoska (12–12–12) 1.000 kg ha^{-1} NH_4NO_3 (26–0–0) 230 kg ha^{-1} . ORG: Plowing (0.2 m), harrowing (0.1–0.2 m). Dried manure with organic C 28%, total N 3%, organic N 2%, C/N ratio 9.3 . AGRO: Tomato in strip cropping with Faba for dry grain (<i>Vicia faba</i> L.). Natural mulching (cover crop flattened) and moving blade. No tillage.
VINEYARD	cv. Sangiovese (<i>Vitis vinifera</i> L.). Soil was tilled (0.25 m) on the row; alleys were covered with a mix of grass species mown 3 times a year. Clay-loam Cambisol soil (WRB-IUSS, 2015) characterized by a neutral pH (6.52), a low content of total N (0.80 g kg^{-1}) and organic matter (1.09 %).	CTRL: No treated control ACM: Municipal organic waste compost applied yearly in spring considering the N rate of $120 \text{ kg N ha}^{-1} \text{ yr}^{-1}$ GDF: Sludge Plasters (product of alkali and acid treatment of sewage sludge) applied yearly in spring considering the N rate of $120 \text{ kg N ha}^{-1} \text{ yr}^{-1}$
CEREAL	Corn and wheat under a biennial rotation. The soil is clay-loamy with a pH of 8.2 and an Electrical conductivity of $348 \mu\text{S cm}^{-1}$.	CONV: Corn and wheat were fertilized with mineral N, P, K fertilizers according to the regional regulations. ORG: Corn and wheat were fertilized with manure and with a supply of mineral N, P, K fertilizers according to plant nutrients requirements and manure nutrient content.
FOREST	Dominant vegetation (95%) belong to the species <i>Fagus sylvatica</i> L., constituting a timber beech forest. The soil is classified as Halpic Luvisols (FAO), with pH values ranging between 5.4 and 5.8 in top 0.40 m. The soil C:N ratio is approximately 11.	0N: The soil only natural Nitrogen deposition. In the studied area total N bulk deposition (including nitrates and ammonium), reaches values of $17.73 \text{ kg N ha}^{-1} \text{ yr}^{-1}$. 30N: The soil received ambient N deposition plus 30 kg N as NH_4NO_3 solution, sprayed on soil surface three times per year in June, July and August. 60N: The soil received ambient N deposition plus $60 \text{ kg N ha}^{-1} \text{ yr}^{-1}$ as NH_4NO_3 solution, sprayed on soil surface three times per year in June, July and August.

Supplementary Table S1. Kruskal-Wallis analysis of results from the principal component analysis (PCA) (Figure 2) with respect to site and management factors.

Parameter	PC1		PC2	
Proportion of variance (%)	53		25	
Kruskal.test Factor	Kruskal-Wallis chi-squared	p-value	Kruskal-Wallis chi-squared	p-value
Sites	83.75	<0.001	72.75	<0.001
Management	28.80	<0.001	3.02	0.390
Sites* Management	85.53	<0.001	78.10	<0.001

Supplementary Table S2. Linear regression model output for the two oxidative enzymatic activities with the other biochemical parameters considered. Significant linear regression are highlighted by a p-value < 0.001.

	pH	TN	SOC	SOC:TN	DOC	TDN	DOC:TDN
Laccase activity							
Intercept	2.942	0.912	0.972	-0.493	0.214	1.292	0.441
Intercept p-value	<0.001	<0.001	<0.001	0.344	0.116	<0.001	<0.001
Parameter	-0.241	0.233	0.019	0.192	0.006	-0.001	0.114
Adj. R-squared	0.185	0.114	0.105	0.105	0.454	-0.007	0.414
p-value	<0.001	<0.001	0.001	0.001	<0.001	0.558	<0.001
Tyrosinase activity							
Intercept	-0.681	1.521	1.477	3.717	1.236	0.846	1.503
Intercept p-value	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Parameter	0.266	-0.226	-0.020	-0.279	-0.0002	0.010	-0.043
Adj. R-squared	0.480	0.230	0.239	0.490	-0.011	0.336	0.110
p-value	<0.001	<0.001	<0.001	<0.001	0.786	<0.001	<0.001

Supplementary Table S3. Linear regression model output of the combined effect of DOC:TDN or SOC:TN with site management on the two oxidative enzymatic activities is reported as the estimated value (p-value). Significant combined effects are highlighted by a p-value < 0.05.

		Laccase - DOC:TDN	Laccase - SOC:TN	Tyrosinase - DOC:TDN	Tyrosinase - SOC:TN
TOMATO	Intercept	0.266 (0.102)	0.765 (0.590)	0.771 (0.202)	1.485 (0.775)
	C:N - CONV	-0.011 (0.728)	0.091 (0.632)	-0.180 (0.147)	0.512 (0.464)
	C:N - ORG	-0.009 (0.870)	-0.017 (0.931)	-0.014 (0.945)	0.082 (0.909)
WALNUT	Intercept	0.831 (0.305)	-0.518 (0.650)	0.457 (0.434)	0.142 (0.862)
	C:N - MIN	0.045 (0.760)	-0.197 (0.350)	-0.075 (0.499)	-0.050 (0.731)
	C:N - ORG	-0.401 (0.096)	-0.625 (0.032)	-0.079 (0.617)	-0.240 (0.190)
VINEYARD	Intercept	2.613 (<0.001)	-1.019 (0.680)	1.710 (0.012)	-8.544 (0.027)
	C:N - CTRL	0.039 (0.240)	-0.442 (0.164)	0.062 (0.272)	-1.264 (0.011)
	C:N - GDF	0.002 (0.967)	-0.243 (0.504)	0.056 (0.479)	-0.693 (0.200)
CEREAL	Intercept	1.886 (0.224)	-28.14 (0.267)	0.571 (0.748)	-48.03 (0.023)
	C:N - ORG	2.266 (0.437)	-4.031 (0.261)	-0.601 (0.861)	-8.228 (0.009)
FOREST	Intercept	1.067 (0.422)	-0.117 (0.944)	0.528 (0.107)	0.706 (0.283)
	C:N - 30N	-0.035 (0.873)	-0.374 (0.504)	0.078 (0.155)	0.217 (0.314)
	C:N - 60N	-0.080 (0.717)	-0.561 (0.257)	-0.052 (0.327)	0.188 (0.317)

Supplementary Table S4. Linear regression model output within each experimental site for the two oxidative enzymatic activities with the DOC:TDN and SOC:TN. Significant linear regression are highlighted by a p-value < 0.001.

		TOMATO	WALNUT	VINEYARD	CEREAL	FOREST
Laccase	Intercept	0.192	0.744	2.221	1.492	1.385
	DOC:TDN	0.002	0.073	0.001	-0.400	0.037
	Adj. R-squared	-0.044	0.098	-0.044	-0.054	-0.035
	p-value	0.876	0.169	0.882	0.526	0.526
Laccase	Intercept	0.823	1.998	1.841	0.649	0.149
	SOC:TN	-0.075	-0.082	0.046	0.011	0.130
	Adj. R-squared	0.063	-0.034	-0.028	-0.099	-0.004
	p-value	0.124	0.442	0.543	0.980	0.348
Tyrosinase	Intercept	1.410	0.694	1.327	0.351	0.479
	DOC:TDN	0.011	-0.005	-0.014	0.971	0.023
	Adj. R-squared	-0.043	-0.097	-0.009	0.073	0.018
	p-value	0.814	0.880	0.383	0.202	0.269
Tyrosinase	Intercept	-0.258	1.328	1.243	4.036	0.550
	SOC:TN	0.208	-0.070	-0.010	-0.252	0.007
	Adj. R-squared	0.018	0.036	-0.045	-0.075	-0.061
	p-value	0.246	0.263	0.938	0.638	0.885

Supplementary Table S5. Linear regression model output for the evaluation of the management effect on the response of the two oxidative enzymatic activities with the DOC:TDN and the SOC:TN parameters. Significant management effects are highlighted by an ANOVA p-value < 0.05 and with the management contrasts – estimate value (p-value).

		Laccase - DOC:TDN	Laccase - SOC:TN	Tyrosinase - DOC:TDN	Tyrosinase - SOC:TN
TOMATO	Intercept	0.315	0.415	1.501	-1.013
	Adj. R-squared	0.383	0.363	0.232	0.330
	ANOVA p-value	0.002	0.008	0.018	0.008
	AGRO-CONV	0.133 (0.002)	0.115 (0.010)	-0.225 (0.222)	-0.128 (0.599)
	AGRO-ORG	0.065 (0.201)	0.038 (0.559)	0.167 (0.500)	0.273 (0.139)
	CONV-ORG	-0.068 (0.106)	-0.077 (0.056)	0.392 (0.016)	0.401 (0.007)
WALNUT	Intercept	0.785	1.058	0.833	0.682
	Adj. R-squared	0.256	0.151	0.463	0.261
	ANOVA p-value	0.190	0.187	0.024	0.141
	CTRL-MIN	0.048 (0.953)	-0.045 (0.957)	-0.140 (0.262)	-0.058 (0.790)
	CTRL-ORG	-0.218 (0.400)	-0.307 (0.228)	-0.280 (0.021)	-0.201 (0.145)
	MIN-ORG	-0.267 (0.192)	-0.262 (0.247)	-0.140 (0.175)	-0.142 (0.260)
VINEYARD	Intercept	2.337	1.945	1.161	-0.082
	Adj. R-squared	-0.126	-0.124	-0.081	-0.059
	ANOVA p-value	0.817	0.944	0.767	0.441
	ACM-CTRL	0.026 (0.979)	0.037 (0.952)	-0.120 (0.846)	-0.093 (0.899)
	ACM-GDF	0.106 (0.802)	0.040 (0.963)	-0.594 (0.825)	-0.340 (0.408)
	CTRL-GDF	0.080 (0.903)	0.018 (0.999)	-0.047 (0.988)	-0.247 (0.637)
CEREAL	Intercept	1.563	-0.025	0.657	9.366
	Adj. R-squared	-0.170	-0.214	-0.006	0.153
	ANOVA p-value	0.904	0.806	0.654	0.087
	CONV-ORG	-0.017 (0.904)	0.041 (0.806)	-0.074 (0.654)	-0.326 (0.087)
FOREST	Intercept	1.411	0.697	0.467	0.367
	Adj. R-squared	0.163	0.106	-0.011	-0.050
	ANOVA p-value	0.089	0.175	0.480	0.364
	0N-30N	0.153 (0.763)	0.115 (0.869)	-0.046 (0.850)	-0.054 (0.813)
	0N-60N	0.520 (0.082)	0.432 (0.172)	-0.107 (0.450)	-0.128 (0.336)
	30N-60N	0.367 (0.251)	0.317 (0.357)	-0.061 (0.761)	-0.074 (0.674)

Supplementary Table S6. Row values (mean and standard deviation) for the measured parameters: soil reaction (pH), total N (TN – g kg_{ds}⁻¹), soil organic C (SOC - g kg_{ds}⁻¹), dissolved organic C (DOC - mg kg_{ds}⁻¹), total dissolved N (TDN - mg kg_{ds}⁻¹), SOC:TN ratio, DOC:TDN ratio, Laccase activity (Lac - μmol ABTS⁺ g_{dw}⁻¹ min⁻¹), and Tyrosinase activity (Tyr - mmol DOPA kg_{dw}⁻¹ h⁻¹).

Site	Management		pH	TN	SOC	SOC:TN	DOC	TDN	DOC:TDN	Lac	Tyr
Walnut	ORG	mean	7.12	0.20	1.80	9.21	74.0	10.7	6.94	1.40	0.78
		st.dev	0.20	0.03	0.21	0.46	5.2	0.5	0.56	0.25	0.11
	CTRL	mean	6.28	0.12	1.21	9.99	41.5	7.74	5.47	1.10	0.57
		st.dev	0.42	0.02	0.27	0.85	3.7	1.68	0.64	0.14	0.06
	MIN	mean	6.41	0.15	1.42	9.45	52.1	7.78	7.04	1.14	0.63
		st.dev	0.55	0.04	0.35	0.57	4.9	2.23	1.89	0.19	0.14
Tomato	AGRO	mean	8.49	1.12	8.97	7.99	68.0	12.7	5.43	0.26	1.43
		st.dev	0.08	0.04	0.38	0.14	6.3	1.9	0.86	0.06	0.27
	ORG	mean	8.37	1.25	10.5	8.41	79.9	21.8	3.73	0.21	1.28
		st.dev	0.07	0.04	0.6	0.30	10.7	4.6	0.54	0.04	0.15
	CONV	mean	8.34	0.79	6.61	8.35	82.1	22.5	4.48	0.14	1.67
		st.dev	0.10	0.05	0.66	0.37	15.4	12.8	1.72	0.08	0.28
Vineyard	CTRL	mean	7.44	0.86	7.70	8.90	227	15.3	16.3	2.24	1.15
		st.dev	0.50	0.08	1.02	0.72	19	5.7	4.6	0.14	0.35
	ACM	mean	7.74	1.61	14.1	8.81	239	18.6	14.3	2.27	1.04
		st.dev	0.32	0.58	4.9	0.34	55	8.7	3.9	0.27	0.50
	GDF	mean	7.13	1.51	11.9	7.94	300	54.2	6.79	2.20	1.27
		st.dev	0.23	0.35	2.3	0.42	40	33.5	2.46	0.29	0.38
Grain	CONV	mean	8.29	0.17	1.25	7.19	209	113	1.86	0.74	2.13
		st.dev	0.04	0.01	0.06	0.03	11	9	0.13	0.23	0.24
	ORG	mean	8.29	0.18	1.30	7.37	222	114	1.95	0.72	2.27
		st.dev	0.05	0.01	0.09	0.16	16	8	0.04	0.18	0.24
Forest	0N	mean	4.50	3.75	43.6	11.6	223	34.8	6.38	1.84	0.58
		st.dev	0.14	0.64	9.2	1.2	49	4.4	0.90	0.55	0.07
	30N	mean	4.35	3.45	39.0	11.3	253	39.7	6.52	1.69	0.62
		st.dev	0.24	0.76	8.7	0.3	70	8.1	2.09	0.26	0.20
	60N	mean	4.30	3.57	40.5	11.4	290	41.0	7.28	1.38	0.70
		st.dev	0.19	0.44	5.1	0.4	59	6.0	2.17	0.25	0.13