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Supplementary material for

Nitrogen and phosphorus availability affect wheat carbon allocation pathways: rhizodeposition and mycorrhizal symbiosis

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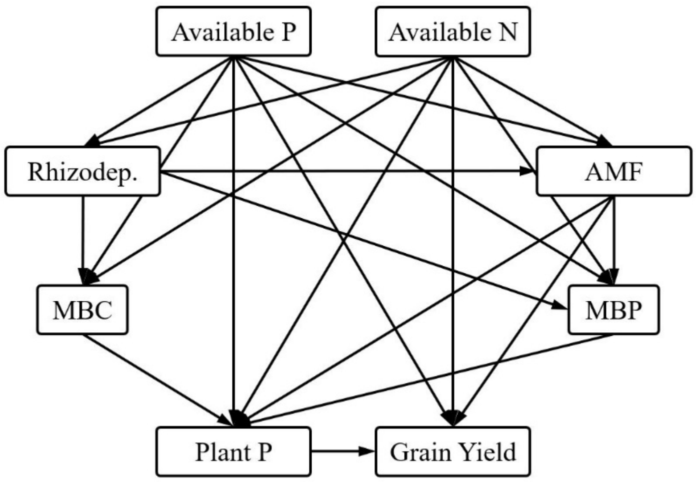

Fig. S1. Structural equation model containing all a priori hypothetical pathways. (Abbreviations: Available P: Soil available phosphorus; Available N: Soil available nitrogen; Rhizodep.: Rhizodeposition; AMF: Arbuscular mycorrhizal fungi colonization; MBC: microbial biomass carbon; MBP: microbial biomass phosphorus; Plant P: Total phosphorus content in aboveground wheat plant part; Grain yield: Grain weight of wheat).

Table S1. Possible priori hypothetical pathways between all of variables in priori model

Arrows indicate the direction of the path

Pathways	References
Available N/P → Rhizodeposition	Gregory *et al*. 1995; Henry *et al*. 2005; Chowdhury *et al*. 2014
Available N/P → Mycorrhizal colonization	Konvalinková *et al*. 2017; Suri *et al*. 2011; Bakhshandeh *et al*. 2017
Available P → Microbial biomass C	Shibahara and Inubushi 1997
Available P → Microbial biomass P	Sugito *et al*. 2010
Available P → Plant phosphorus	Romer and Schilling 1986
Available P → Grain yield	Takahashi and Anwar 2007; Xin-kai *et al*. 2012
Available N → Microbial biomass C	Treseder 2008
Available N → Microbial biomass P	Shen *et al*. 2016
Available N → Plant phosphorus	Mehta *et al*. 1963
Available N → Grain yield	Zhang *et al*. 2017; Bashirov 2009
Rhizodeposition → Mycorrhizal colonization	Bécard and Piché 1989, Waters *et al*. 2017
Rhizodeposition → Microbial biomass C	Nguyen 2009
Rhizodeposition → Microbial biomass P	Spohn et al. 2013
Mycorrhizal colonisation → Microbial biomass P	Toljander *et al*. 2007
Mycorrhizal colonisation → Plant phosphorus	Campos *et al*.2018
Mycorrhizal colonisation → Grain yield	Bakhshandeh *et al*., 2017
Microbial biomass C → Plant phosphorus	Spohn and Kuzyakov 2013
Microbial biomass P → Plant phosphorus	Sugito *et al*. 2010
Plant phosphorus → Grain yield	Sandana and Pinochet 2014

Table S2. Effect of genotype (G), phosphorus (P) and nitrogen (N) fertiliser on root biomass, specific root length (SRL), root diameter (RD), proportion of fine (0.01–0.2 mm), intermediate (0.2–1 mm) and coarse (1–2 mm) diameter roots at tillering stage (mean ± s.e.m.)

ANOVA *P*-values are in bold when $P < 0.05$ and different letters in each column indicate significant differences among G treatments (*post hoc* Tukey's HSD test results are only shown for significant main or interactive effects of G)

Genotype	Phosphorus levels (kg ha^{-1})	Nitrogen levels (kg ha^{-1})	SRL (m g^{-1})	Average diameter (mm)	Proportion of fine diameter roots (0.01 – 0.2 mm)	Proportion of intermediate diameter roots (0.2 – 1 mm)	Proportion of coarse diameter roots (1 – 2 mm)
249	40	100	65.1 ± 27	0.27 ± 0.021	0.430 ± 0.045 b	0.560 ± 0.043 a	0.011 ± 0.005
	40	25	130.0 ± 41	0.24 ± 0.006	0.529 ± 0.025 b	0.468 ± 0.025 a	0.003 ± 0.001
	10	100	92.3 ± 41	0.26 ± 0.017	0.484 ± 0.013 b	0.500 ± 0.015 a	0.016 ± 0.011
	10	25	161.3 ± 29	0.24 ± 0.005	0.532 ± 0.009 b	0.461 ± 0.011 a	0.007 ± 0.002
IAW2013	40	100	93.1 ± 32	0.24 ± 0.010	0.515 ± 0.019 a	0.479 ± 0.019 b	0.006 ± 0.002
	40	25	81.3 ± 25	0.23 ± 0.004	0.570 ± 0.012 a	0.427 ± 0.011 b	0.003 ± 0.002
	10	100	179.3 ± 28	0.23 ± 0.003	0.559 ± 0.023 a	0.435 ± 0.024 b	0.006 ± 0.002
	10	25	103.5 ± 27	0.24 ± 0.012	0.561 ± 0.026 a	0.427 ± 0.028 b	0.013 ± 0.006
Scout	40	100	171.2 ± 50	0.25 ± 0.006	0.485 ± 0.004 b	0.511 ± 0.007 a	0.004 ± 0.003
	40	25	148.2 ± 22	0.24 ± 0.002	0.501 ± 0.011 b	0.495 ± 0.012 a	0.003 ± 0.002
	10	100	118.4 ± 54	0.25 ± 0.007	0.494 ± 0.016 b	0.500 ± 0.017 a	0.005 ± 0.001
	10	25	155.6 ± 31	0.25 ± 0.003	0.496 ± 0.016 b	0.499 ± 0.017 a	0.005 ± 0.001
Suntop	40	100	75.9 ± 28	0.25 ± 0.011	0.509 ± 0.054 ab	0.483 ± 0.055 ab	0.008 ± 0.003
	40	25	161.1 ± 21	0.24 ± 0.005	0.517 ± 0.021 ab	0.474 ± 0.020 ab	0.008 ± 0.002
	10	100	91.6 ± 38	0.24 ± 0.003	0.525 ± 0.024 ab	0.468 ± 0.028 ab	0.007 ± 0.004
	10	25	121.7 ± 57	0.24 ± 0.011	0.544 ± 0.030 ab	0.448 ± 0.029 ab	0.008 ± 0.004
ANOVA *p* values							
G			0.4355	0.1589	**0.0058**	**0.0066**	0.5010
P			0.5098	0.7802	0.1824	0.1341	0.2149
N			0.2387	0.0751	**0.0172**	**0.0263**	0.4704
G*P			0.4248	0.8763	0.8991	0.8789	0.7459
G*N			0.1377	0.3004	0.2629	0.4129	0.3033
P*N			0.7102	0.3232	0.2863	0.3423	0.5634
G*P*N			0.6072	0.6907	0.7762	0.8146	0.8086

Table S3. Effect of genotype (G), phosphorus (P) and nitrogen (N) fertiliser on δ^{13}C root, δ^{13}C soil and δ^{13}C MB at ripening stage (mean ± s.e.m.)

ANOVA *P*-values are in bold when *P* < 0.05 and different letters in each column indicate significant differences among G treatments based on *post hoc* Tukey's HSD test

Genotype	Phosphorus levels (kg ha^{-1})	Nitrogen levels (kg ha^{-1})	δ^{13}C Roots (‰)	δ^{13}C Soil (‰)	δ^{13}C MB (‰)
249	40	100	–37.49 ± 0.55 ab	–23.16 ± 0.14 b	–26.78 ± 0.28 b
	40	25	–37.84 ± 0.24 ab	–23.25 ± 0.06 b	–28.08 ± 1.13 b
	10	100	–37.60 ± 0.34 ab	–23.36 ± 0.16 b	–29.87 ± 2.66 b
	10	25	–37.49 ± 0.26 ab	–23.44 ± 0.30 b	–27.69 ± 0.27 b
IAW2013	40	100	–37.66 ± 0.62 b	–22.94 ± 0.03 a	–25.14 ± 0.83 a
	40	25	–38.57 ± 0.20 b	–22.92 ± 0.11 a	–24.57 ± 0.27 a
	10	100	–38.72 ± 0.97 b	–23.04 ± 0.03 a	–23.05 ± 2.09 a
	10	25	–37.89 ± 0.35 b	–22.90 ± 0.08 a	–24.48 ± 0.49 a
Scout	40	100	–36.80 ± 0.19 a	–23.20 ± 0.10 ab	–24.87 ± 0.21 a
	40	25	–37.03 ± 0.32 a	–23.13 ± 0.12 ab	–24.12 ± 0.23 a
	10	100	–36.92 ± 0.93 a	–22.97 ± 0.13 ab	–23.06 ± 1.70 a
	10	25	–37.59 ± 0.32 a	–23.03 ± 0.10 ab	–27.28 ± 1.47 a
Suntop	40	100	–36.37 ± 0.48 a	–23.18 ± 0.18 ab	–23.97 ± 1.21 a
	40	25	–35.79 ± 0.41 a	–22.82 ± 0.16 ab	–25.06 ± 0.65 a
	10	100	–37.05 ± 0.19 a	–23.02 ± 0.06 ab	–22.56 ± 0.55 a
	10	25	–37.24 ± 1.09 a	–23.23 ± 0.17 ab	–22.94 ± 1.35 a
ANOVA *p* values					
G			**0.001**	**0.006**	**<0.0001**
P			0.2	0.5	0.8
N			0.7	0.7	0.3
G×P			0.5	0.2	0.2
G×N			0.9	0.8	0.6
P×N			0.7	0.3	0.6
G×P×N			0.3	0.3	0.1

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