Supporting Information. Worthy, S. J., D. C. Laughlin, J. Zambrano, M. N. Umaña, C. Zhang, L. Lin, M. Cao, and N. G. Swenson. 2020. Alternative designs and tropical tree seedling growth performance landscapes. Ecology.

APPENDIX S1

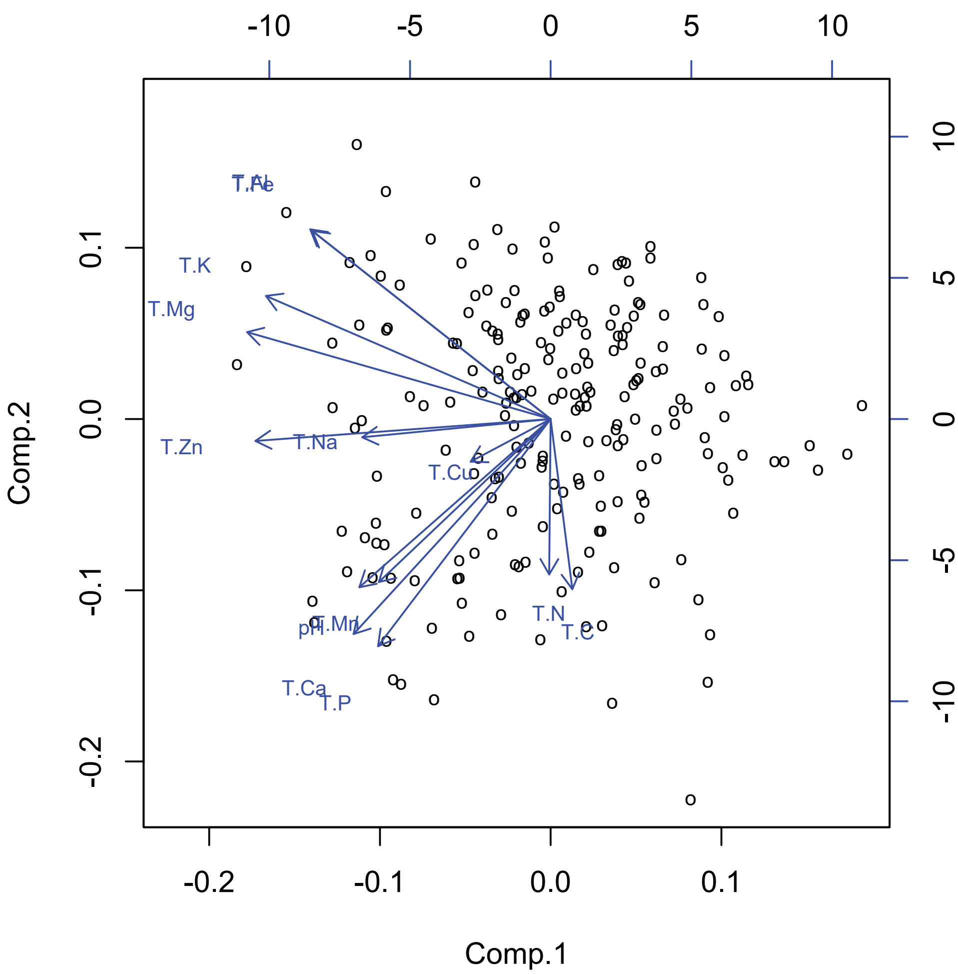

Fig. S1. Principal components analysis of the soil properties measured for each of the 215 seedling plots (shown as circles). The first three orthogonal axes, explaining 78% of the total soil variation, were used for analyses. PC1 scores were negatively associated with K, Mg and Zn, PC2 scores were negatively associated with Ca and P, and PC3 scores were negatively associated with C and N.

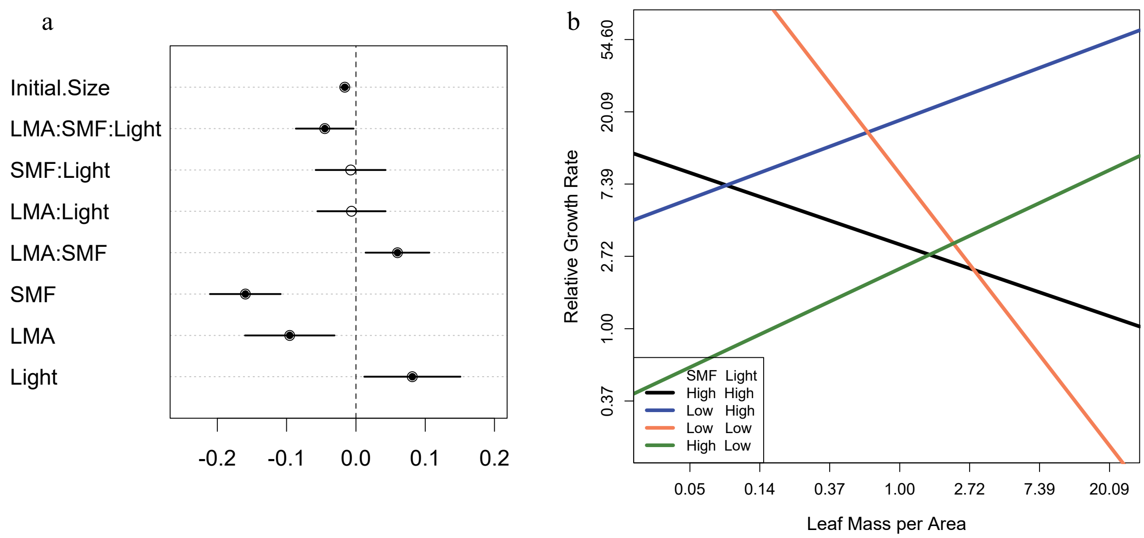

Fig. S2. Model including three-way interaction between leaf mass per area (LMA), stem mass fraction (SMF), and light. a) Standardized regression coefficients where circles indicate posterior mean values, lines indicate 95% credible intervals, and filled circles represent significant effects. b) Simple slopes and intercepts visualizing the partial effects of LMA on RGR when SMF and light are held constant at combinations of their minimum (SMF = 0.04, Light = 0.66) and maximum (SMF = 0.90, Light = 10.10) values. All variables were scaled and natural log-transformed. Values on the axes have been back transformed. In low light environments, there are two growth performance peaks for individuals, one when they have both low LMA and SMF and one when they have both high LMA and SMF. In high light environments, there are two performance peaks for individuals, one where they have low LMA and high SMF and one where they have high LMA and low SMF.

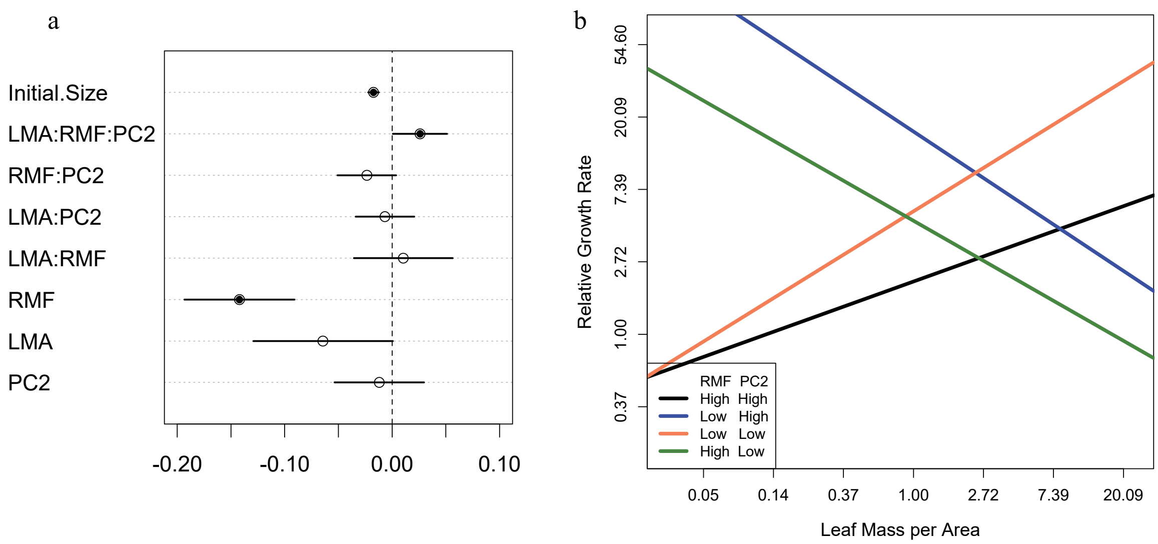

Fig. S3. Model including three-way interaction between leaf mass per area (LMA), root mass fraction (RMF), and soil PC2. a) Standardized regression coefficients where circles indicate posterior mean values, lines indicate 95% credible intervals, and filled circles represent significant effects. b) Simple slopes and intercepts visualizing the partial effects of LMA on RGR when RMF and soil PC2 are held constant at combinations of their minimum (RMF = 0.04, PC2 = 0.004) and maximum (RMF = 0.93, PC2 = 49.64) values. All variables were scaled and natural log-transformed. Values on the axes have been back transformed. In order for individuals to be on a growth performance peak in low soil PC2 environments, meaning high Ca and P, they need high LMA and low RMF or low LMA and high RMF. In high soil PC2 environments, individuals with high LMA and high RMF or low LMA and low RMF exhibit peak growth performance.

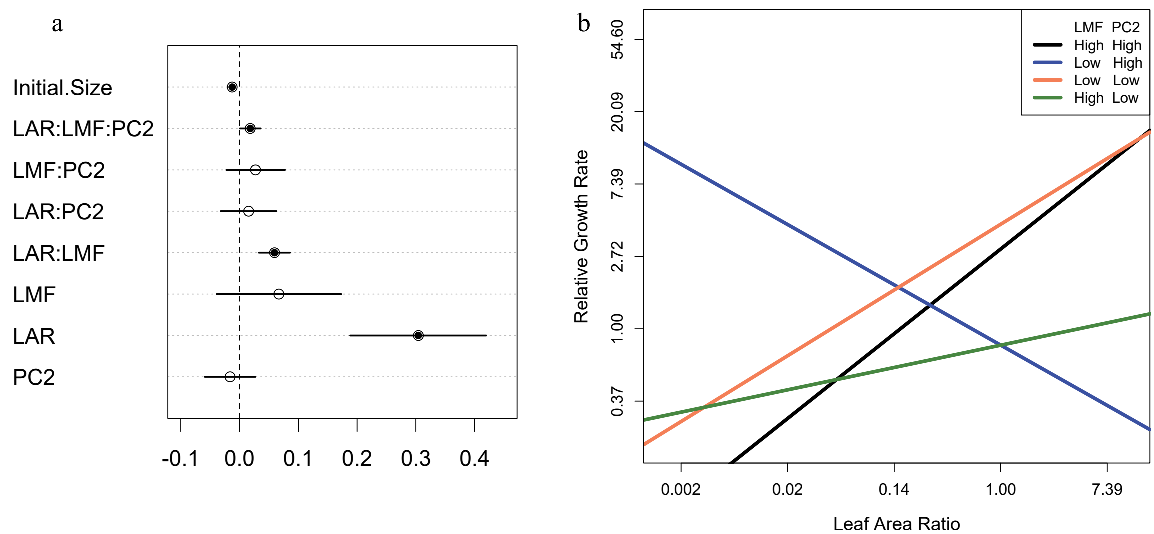

Fig. S4. Model including three-way interaction between leaf area ratio (LAR), leaf mass fraction (LMF), and soil PC2. a) Standardized regression coefficients where circles indicate posterior mean values, lines indicate 95% credible intervals, and filled circles represent significant effects. b) Simple slopes and intercepts visualizing the partial effects of LAR on RGR when LMF and soil PC2 are held constant at combinations of their minimum (LMF = 0.02, PC2 = 0.004) and maximum (LMF = 0.68, PC2 = 49.64) values. All variables were scaled and natural log-transformed. Values on the axes have been back transformed. In order for individuals to be on a growth performance peak in low soil PC2 environments, meaning high Ca and P, they need high LAR and low LMF or high LAR and high LMF. In high soil PC2 environments, individuals with high LAR and high LMF or low LAR and low LMF exhibit peak growth performance.

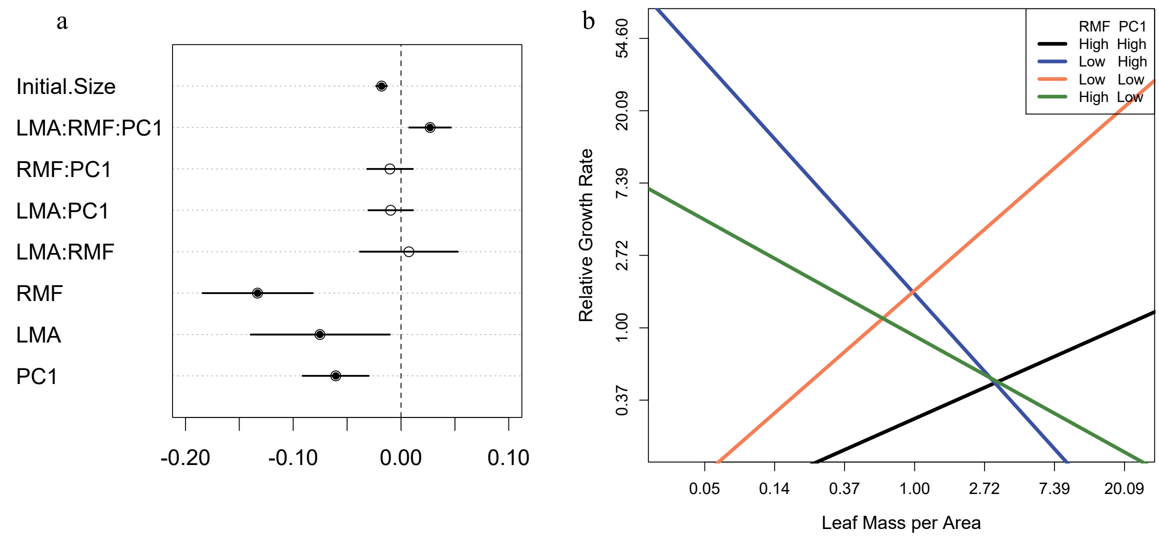

Fig. S5. Model including three-way interaction between leaf mass per area (LMA), root mass fraction (RMF), and soil PC1. a) Standardized regression coefficients where circles indicate posterior mean values, lines indicate 95% credible intervals, and filled circles represent significant effects. b) Simple slopes and intercepts visualizing the partial effects of LMA on RGR when RMF and soil PC1 are held constant at combinations of their minimum (RMF = 0.04, PC1 = 0.002) and maximum (RMF = 0.93, PC1 = 411.00) values. All variables were scaled and natural log-transformed. Values on the axes have been back transformed. In order for individuals to be on a growth performance peak in low soil PC1 environments, meaning high values of MG, K and Zn, they need high LMA and low RMF or low LMA and high RMF. In high soil PC1 environments, individuals with high LMA and high RMF or low LMA and low RMF exhibit peak growth performance.

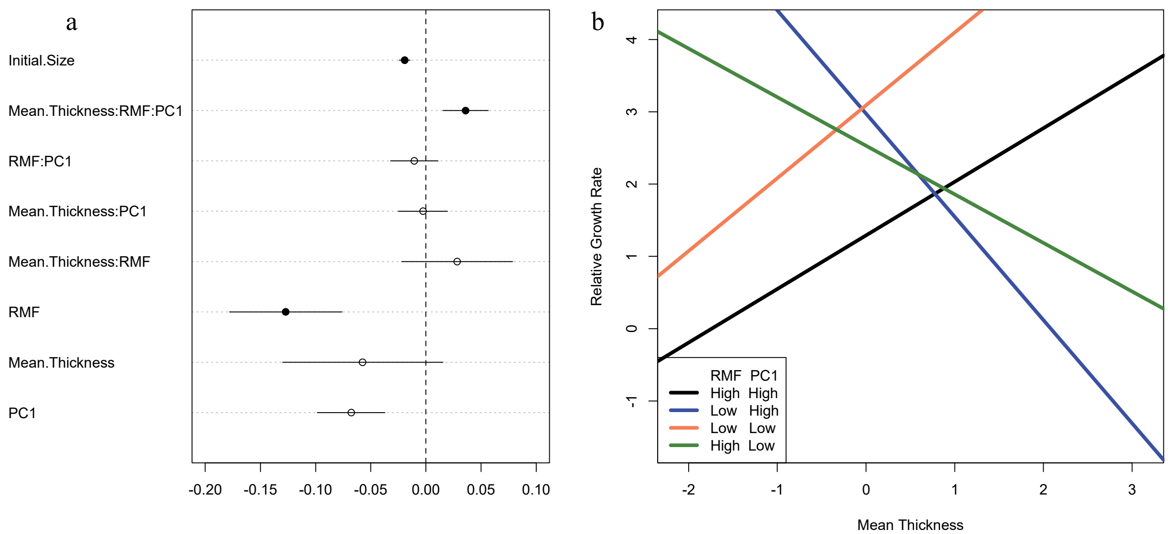

Fig. S6. Model including three-way interaction between mean leaf thickness, root mass fraction (RMF), and soil PC1. a) Standardized regression coefficients where circles indicate posterior mean values, lines indicate 95% credible intervals, and filled circles represent significant effects. b) Simple slopes and intercepts visualizing the partial effects of mean thickness on RGR when RMF and soil PC1 are held constant at combinations of their minimum (RMF = 0.04, PC1 = 0.002) and maximum (RMF = 0.93, PC1 = 411.00) values. All variables were scaled and natural log-transformed. Values on the axes have been back transformed. In order for individuals to be on a growth performance peak in low soil PC1 environments, meaning high values of MG, K and Zn, they need high mean thickness and low RMF or low mean thickness and high RMF. In high soil PC1 environments, individuals with high mean thickness and high RMF or low mean thickness and low RMF exhibit peak growth performance.

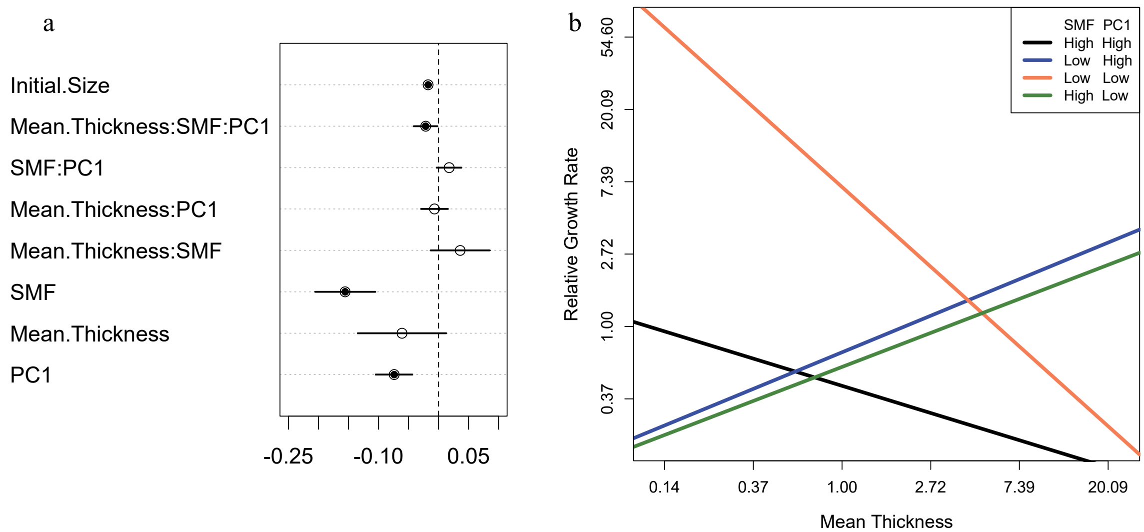

Fig. S7. Model including three-way interaction between mean leaf thickness, stem mass fraction (SMF), and soil PC1. a) Standardized regression coefficients where circles indicate posterior mean values, lines indicate 95% credible intervals, and filled circles represent significant effects. b) Simple slopes and intercepts visualizing the partial effects of mean thickness on RGR when SMF and soil PC1 are held constant at combinations of their minimum (SMF = 0.04, PC1 = 0.002) and maximum (SMF = 0.90, PC1 = 411.00) values. All variables were scaled and natural log-transformed. Values on the axes have been back transformed. In order for individuals to be on a growth performance peak in low soil PC1 environments, meaning high values of MG, K and Zn, they need low mean thickness and low SMF or high mean thickness and high SMF. In high soil PC1 environments, individuals with high mean thickness and low SMF or low mean thickness and high SMF exhibit peak growth performance.

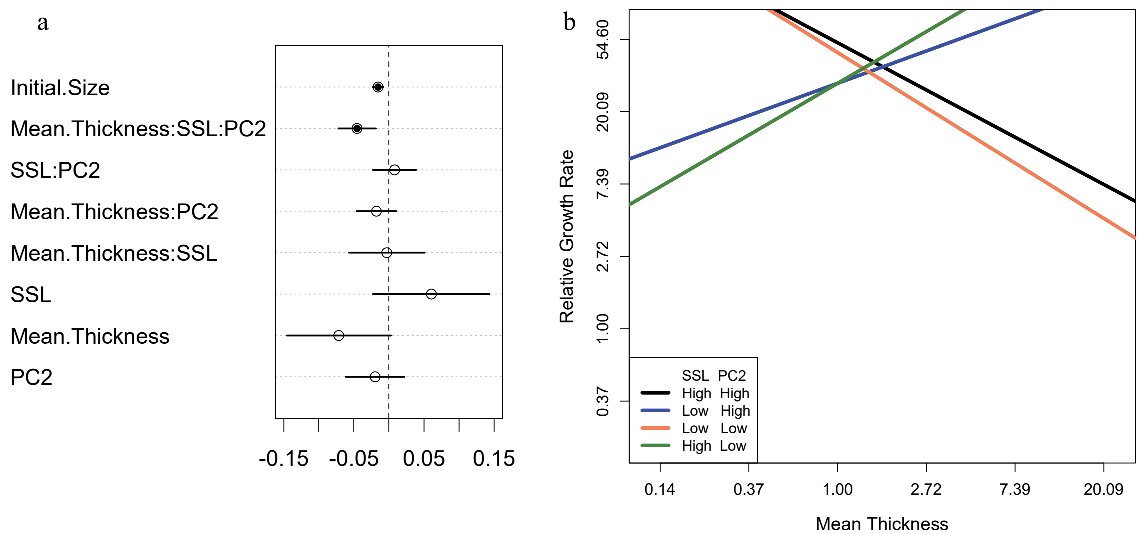

Fig. S8. Model including three-way interaction between mean leaf thickness, stem specific length (SSL), and soil PC2. a) Standardized regression coefficients where circles indicate posterior mean values, lines indicate 95% credible intervals, and filled circles represent significant effects. b) Simple slopes and intercepts visualizing the partial effects of mean thickness on RGR when SSL and soil PC2 are held constant at combinations of their minimum (SSL = 2.47, PC2 = 0.004) and maximum (SSL = 415.00, PC2 = 49.64) values. All variables were scaled and natural log-transformed. Values on the axes have been back transformed. In order for individuals to be on a growth performance peak in low soil PC2 environments, meaning high Ca and P, they need low mean thickness and low SSL or high mean thickness and high SSL. In high soil PC2 environments, individuals with low leaf thickness and high SSL or high mean thickness and low SSL exhibit peak growth performance.

Table S1. Ranges of observed values for functional traits and relative growth rate for all 1559 individuals.

Trait	Min	Max	Mean
Leaf Mass per Area (g/cm^2)	0.001	0.010	0.004
Leaf Mass Fraction	0.018	0.678	0.334
Root Mass Fraction	0.041	0.932	0.309
Stem Mass Fraction	0.041	0.899	0.356
Mean Leaf Thickness (mm)	0.082	0.400	0.163
Stem Specific Length (cm/g)	2.467	415.000	55.413
Leaf Area Ratio (cm^2/g)	3.121	262.072	86.022
Relative Growth Rate (cm/year)	0.000	0.762	0.180

Table S2. Soil nutrient concentration and percent of light availability ranges for all 215 seedling plots.

Environmental Variable	Min (g/kg)	Max (g/kg)	Mean (g/kg)
C	6.00	30.03	16.07
N	0.59	2.90	1.76
P	0.24	0.74	0.39
K	6.77	19.57	11.73
Ca	0.11	3.71	0.68
Mg	2.42	10.24	4.70
Na	0.27	1.41	0.55
Cu	0.01	0.06	0.02
Zn	0.02	0.09	0.04
Fe	13.63	32.66	21.84
Mn	0.11	1.36	0.60
Al	25.80	61.61	40.10
pH	4.36	6.02	5.05
% light	0.66	10.11	2.71

Table S3. Principal component analysis loadings of the soil variables with cumulative proportion of variance explained by each axis. The first three orthogonal axes were used for analyses.

Variable	Comp.1	Comp.2	Comp.3
Total C	0.029	-0.309	-0.557
Total N	-0.002	-0.283	-0.574
Total P	-0.232	-0.413	-0.189
Total K	-0.383	0.224	-0.122
Total Ca	-0.265	-0.391	0.145
Total Mg	-0.409	0.158	-0.080
Total Na	-0.254	-0.033	-0.068
Total Cu	-0.108	-0.077	0.155
Total Zn	-0.397	-0.040	0.098
Total Fe	-0.321	0.342	-0.174
Total Mn	-0.232	-0.297	0.245
Total Al	-0.323	0.344	-0.184
pH	-0.258	-0.306	0.348
Cumulative proportion	0.391	0.605	0.774

Table S4. Pearson's product-moment correlation coefficients for combinations of functional traits. P-values in bold are significant. Results of variance inflation factor (VIF) analysis. A value of 1 means no correlation.

Trait Variables	**Correlation**	**P value**	**VIF**
LMA x RMF	-0.02	0.35	1.00
LMA x SMF	-0.21	**< 0.001**	1.05
Mean Thickness x SSL	-0.22	**< 0.001**	1.05
Mean Thickness x SMF	-0.12	**< 0.001**	1.01
Mean Thickness x RMF	0.18	**< 0.001**	1.04
LAR x LMF	0.83	**< 0.001**	3.23

Table S5. Mean values of the slope of the first partial derivative of each model along with upper and lower 95% confidence intervals (CI). Confidence intervals were generated by randomly sampling, with replacement, 1000 iterations of the MCMC chains where the slope for each iteration was calculated.

Interaction	**Mean Slope**	**Lower CI Slope**	**Upper CI Slope**
RMF x Light	-0.06297	-0.1099652	-0.0152051
LMA x RMF x Light	0.05305	0.01492716	0.09167430
LMA x SMF x Light	-0.044880	-0.086024456	-0.005162304
LMA x RMF x PC2	0.025980	0.001135489	0.050253354
LAR x LMF x PC2	0.01824	0.000331546	0.035933937
LMA x RMF x PC1	0.026960	0.008358551	0.047113183
Thick x RMF x PC1	0.03601	0.01707626	0.05638533
Thick x SMF x PC1	-0.021470	-0.040348208	-0.001576769
Thick x SSL x PC2	-0.04548	-0.07253712	-0.02024327

Table S6. Determination of the presence of multiple growth performance peaks at each end of the environmental gradient. Each interaction is presented along with the two ends of the environmental gradient where the presence of multiple growth performance peaks was tested. The posterior distributions were randomly sampled, with replacement, 1000 times for each model. Each of the simples slopes was calculated for each random iteration. The number of times the slopes differed in sign for two growth performance peaks at the same end of the environmental gradient was determined (Number of Different Slopes). An exact binomial test with a probability of success equal to 0.50 was used to test for significant differences, with a p value of < 0.05 indicating the presence of two growth performance peaks at the same end of the environmental gradient.

Interaction	Environment	Number of Different Slopes	P Value
LMA x RMF x Light	High Light	972	< 0.001
LMA x RMF x Light	Low Light	981	< 0.001
LMA x SMF x Light	High Light	839	< 0.001
LMA x SMF x Light	Low Light	994	< 0.001
LMA x RMF x PC2	High PC2	937	< 0.001
LMA x RMF x PC2	Low PC2	952	< 0.001
LAR x LMF x PC2	High PC2	964	< 0.001
LMA x RMF x PC1	High PC1	979	< 0.001
LMA x RMF x PC1	Low PC1	993	< 0.001
Thick x RMF x PC1	High PC1	998	< 0.001
Thick x RMF x PC1	Low PC1	995	< 0.001
Thick x SMF x PC1	High PC1	918	< 0.001
Thick x SMF x PC1	Low PC1	987	< 0.001
Thick x SSL x PC2	High PC2	974	< 0.001
Thick x SSL x PC2	Low PC2	998	< 0.001

Table S7. Standardized regression coefficient posterior means (95% credible intervals) and goodness-of-fit statistics including the deviance information criterion (DIC) and Bayesian *p*-values for the two single trait models.

Model	**Coefficient**	**P value**	**DIC**
RGR ~ LMA + initial size	-0.10 (-0.16, -0.03)	0.5005	3926
RGR ~ RMF + initial size	-0.14 (-0.19, -0.08)	0.5015	3894

Table S8. Pearson's product-moment correlation coefficients between light and soil variables. P-values in bold are significant at $P < 0.05$.

Environmental Variables	Correlation	P value
Light x Soil PC 1	-0.15	**0.03**
Light x Soil PC 2	-0.11	0.10
Light x Soil PC 3	0.06	0.35