Journal: *eLife*

Diversity-induced plant history and soil history effects modulate plant responses to global change

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Abstract

Global change has dramatic impacts on grassland diversity. However, little is known about how fast species can adapt to these changes and how this affects their responses to global change. To close this gap, we performed a common garden experiment testing whether plant responses to global change are influenced by the selection history of the plants and the conditioning history of soil at different levels of plant diversity. Therefore, we collected seeds and took soil samples from 14-year old plant communities of a biodiversity experiment. Offspring of plants from low- and high-diversity communities were either grown in their own soil or in soil of a different community, and were either exposed to drought, increased nitrogen input, or a combination of both. Results show that, under nitrogen addition, offspring of plants selected at high diversity produced more biomass than those selected at low diversity, while drought neutralized differences in biomass production. Moreover, under the influence of global change drivers, mainly soil, and to a lesser extent plant history, influenced the expression of plant traits. Our results show that plant diversity modulates plant-soil interactions and growth strategies of plants, which feedback on the eco-evolutionary pathways of the plants and thus their responses to global change.

Key words: plant-soil interaction, plant-soil feedback, drought, fertilization, micro-evolution, eco-evolutionary feedback, nutrient enrichment, climate change

Introduction

Human activities, such as the combustion of fossil fuels and the intensification of agriculture, are leading to global environmental changes, causing increased air temperatures, altered precipitation patterns, and rising amounts of nitrogen to ecosystems (IPCC, Pörtner et al. 2021). The consequences are more frequent extreme weather events such as droughts (Dai et al. 2018) and a growing accumulation of nitrogen in the soils (Holland et al. 2005). Both, drought and increased nitrogen input, in turn, further influence ecosystems and climatic conditions; hence, they are known as major global change drivers (Sage 2020).

Some of the most tremendous negative effects of global change are changes in ecological communities (Dornelas et al. 2014) and the extinction of species (Sage 2020), whereby plant species are particularly concerned due to their low mobility, with drastic consequences for the functioning of ecosystems. Studies in grassland biodiversity experiment have shown that low- and high-diversity plant communities significantly differ in their productivity and stability (Isbell et al. 2015; Marquard et al. 2009; Tilman et al. 2006). Low-diversity communities were shown to lose productivity over time, while high-diversity communities are more stable, so that plant diversity-productivity relationships become more positive over time (Cardinale et al. 2007; Meyer et al. 2016; Reich et al. 2012). The different development of plant-soil and plant-plant interactions at low and high diversity are assumed to be the important drivers of this strengthening biodiversity effect (Eisenhauer et al. 2019; Thakur et al. 2021). At low plant diversity, an accumulation of soil-borne pathogens might be responsible for lower plant community productivity (Mommer et al. 2018; Thakur et al. 2021), while in high-diversity communities, complementarity effects among plants inhibit such negative processes, causing a higher productivity of these plant communities (Cardinale et al. 2007; Reich et al. 2012). Consequently, these findings raise the question, whether populations of the same plant species develop differently over time when growing at high or low diversity due to differences in eco-evolutionary feedbacks (Bailey et al. 2006; Linhart 1988; Post and Palkovacs 2009; terHorst and Zee 2016). Indeed, there is empirical evidence that plant individuals at high diversity are selected for greater niche complementarity among species leading to a more complete use of available resources (Zuppinger-Dingley et al. 2014). At low plant diversity, however, the accumulation of soil-borne pathogens may cause persistent species to adapt to this increase by producing more defense compounds, so that over time selection favors individuals that invest more in defense and less in growth (Eisenhauer et al. 2019).

Taken together, low and high plant diversity may differently affect eco-evolutionary feedbacks and thus the microevolution of plants, which could have the effect that plants selected at low diversity respond differently to global change drivers than plants selected at high diversity, due to differences in the phenotype and/or growth strategies. In a previous transplant experiment (Lipowsky et al. 2011), it was shown that some of the studied grassland species showed difference in their phenotype depending on plant history (monoculture or mixture) and soil environment (home or away soil). For example, it was shown that the species *Cirsium oleraceum* (L.) Scop. had a higher number of leaves, when originated from mixture communities, and were taller, when grown in home soil. Furthermore, several greenhouse studies showed similar results, i.e., that plants selected at low or high diversity or grown with "own" or different soil biota vary in their productivity and trait expression (Hahl et al. 2020; van Moorsel et al. 2018b; Zuppinger-Dingley et al. 2014). Such diversity-induced differences in the phenotype could lead to different responses of plants to global change drivers. For example, it is possible that, due to differences in leaf number or root structure, plants selected at low diversity have a lower resistance against drought than plants selected at high diversity. Such changes would contribute to a faster extinction of species, which makes research into these processes an essential frontier.

In summary, differences in plant-plant and plant-soil interactions at low and high diversity may lead to differences in eco-evolutionary feedbacks; however, little is known about how rapidly and pervasively these differences occur (terHorst and Zee 2016). Moreover, it is not known whether these differences affect the response of plants to global change drivers (Pugnaire et al. 2019), such as drought, nitrogen input or a combination of both, which is assumed to be a common scenario in the future (Craven et al. 2016; Sage 2020). To address these knowledge gaps, we performed a common garden experiment using plant and soil material from a long-running biodiversity experiment (Jena Experiment). For our study, we collected seeds of four grass species and took samples of soil biota (soil samples), which both had been selected for 14 years, either at low or high diversity (communities with two or six plant species and different plant species composition). Plants were grown either in soil inoculated with their home soil biota, i.e. soil biota of the community, where the seeds had been collected, or in soil inoculated with away soil biota, i.e. with soil biota of a different plant community (differing in plant diversity or composition). The aim of the study was to test, whether plant history (origin of plants), soil history (origin of soil biota), and soil treatment (home/away) influence the response of the plants to global change. Therefore, plants were either non-treated (control), or exposed to drought, increased nitrogen input, or a combination of both, drought and nitrogen input, in a full factorial design. We hypothesized that

(I) plant and soil communities develop differently at low and high diversity over time. Therefore, we expected that offspring of plants (Ia) selected at high diversity generally shows higher biomass production compared to offspring selected at low diversity in the control, and that plants under control conditions produce more biomass (Ib) in home than in away soil and (Ic) in high-diversity than in low-diversity soil. Further, (Id) we supposed effects of plant history, soil history, and soil treatment on trait expression of control plants. For example, we expected that offspring of plants from high-diversity communities show higher values for traits related to relative growth rates (e.g., leaf greenness, specific leaf area) and nutrient economy (e.g., shoot nitrogen concentrations) than offspring of plants from low-diversity communities.

(II) global change drivers have a strong impact on biomass production and trait expression of plants. We expected that (IIa) drought reduces, and (IIb) nitrogen input increases plant biomass, while (IIc) the combination of both global change drivers has no impact on plant biomass production, because drought and nitrogen input compensate each other’s impact.

(III) because of different development of plants and soil communities at low and high diversity, offspring of plants (IIIa) selected at different diversity and grown in different soil (IIIb: home vs. away soil, IIIc: soil from low- vs. high-diversity communities) respond differently to global change drivers regarding performance and trait expression.

Results

Hypothesis 1: offspring of plants selected at different diversity and grown in different soil (high vs. low diversity, home vs. away) show differences in productivity and trait expression

Biomass production

Plants grown in soil of six-species communities tended to produce more root biomass than plants in soil of two-species communities in the control (Table 3; Fig. 2). At species-level, *A. elatius* produced more root biomass and had higher root-shoot ratio, and *D. glomerata* produced more shoot and total biomass in soil of six-species than two-species communities (Fig. 2, 3a; Appendix S3: Table S8, S10). The other two species, *P. trivialis* and *A. pratensis* did not differ significantly in biomass production dependent on soil or plant history (Fig. 2, 3a; Appendix S3: Table S9, S11). Initial shoot number showed no influence on later biomass production except for shoot biomass of *D. glomerata* and root biomass of *A. elatius*, which, however, did not change the general patterns.

Plant traits and pathogen infestation

Legacy treatments had no consistent effects across the four species on the expression of shoot, leaf, or root traits in the control (Appendix S3: Table S1). At species-level, legacy treatments did not affect trait expression in *A. elatius* (Fig. 3a; Appendix S3: Table S1). Plants of *A. pratensis* were taller in home than in away-different soil and had thicker roots (higher root diameter) in six- than in two-species soil (Fig. 3a; Appendix S3: Table S3). Plants of *D. glomerata* had higher leaf greenness and stomatal conductance, when seeds originated from two-species communities (Fig. 3a; Appendix S3: Table S4). Plants of *P. trivialis* had lower shoot nitrogen concentration and root diameter, and higher SRL in home soil than in away soil (Fig. 3a; Appendix S3: Table S5).

We found a low pathogen infestation of *A. elatius* and *A. pratensis* (0.8% ± 1.9% (SD) and 0.1% ± 0.5%, respectively), mainly by the rust species *Puccinia graminis* Pers. and *Puccinia coronata* Corda. Plants of *D. glomerata* and *P. trivialis*, in contrast, were strongly infested by the mildew *Blumeria graminis* (DC.) Speer (3.1% ± 4.2% and 8.6% ± 16.5%, respectively). Regarding legacy treatments, *D. glomerata* plants had a lower infestation when grown in home soil than in away soil, while mildew infestation of *P. trivialis* plants did not differ between legacy treatments (Fig 3a; Appendix S3: Table S6).

Hypothesis 2: global change drivers have a strong impact on biomass production and trait expression.

Biomass production

Overall, global change drivers had a strong impact on almost all response variables (Table 2; Fig. 3b-d; Appendix S2: Table S1-9). Compared to control plants, drought reduced shoot biomass production, which was found across all study species and at species-level (Fig. 4a, d). In contrast, drought did not have consistent effects on root biomass (Fig. 4a, d). Drought had positive impact on root biomass of *A. elatius* and *D. glomerata*, while root biomass of *A. pratensis* decreased under drought and did not change significantly in *P. trivialis* (Fig. 4d).

Total biomass production was decreased, when plants were exposed to drought (Fig. 4a, d) except for *D. glomerata*, where it was not different from the control (Fig. 4d). Root-shoot ratios increased under drought (Fig. 4a, d), which was found for all species except for *P. trivialis* (no significant change; Fig. 4d).

Nitrogen input increased shoot, root, and thus also total biomass across the four species (Fig. 4b) as well as in separate analyses of *A. elatius* and *A. pratensis* (Fig. 4e). Plants of *D. glomerata* and *P. trivialis* did not change in root biomass when fertilized (Fig. 3e). Nitrogen input caused a decrease in root-shoot ratio in all species (Fig. 4a, e).

When plants were treated with both global change drivers in combination, the negative impact of drought on shoot biomass was cancelled out by the positive impact of nitrogen input leading to an overall slight increase of shoot biomass (compared to control plants) that was also significant at the species-level except for *A. elatius* (Fig. 4c, f). Consistent with this, the positive impact of nitrogen input on root biomass was also cancelled out by drought when plants were treated with both global change drivers, i.e. control plants and plants treated with both global change drivers did not differ in root biomass production, across all study species (Fig. 4c). At species-level, the combination of both global change drivers had an additive effect on root biomass production of *A. elatius* and *D. glomerata*, i.e. plants of both species showed highest root biomass when treated with both global change drivers (Fig. 4f). In *A. pratensis* and *P. trivialis*, both global change drivers in combination decreased root biomass production (Fig. 3f). Taken together, the combination of both global change drivers led to a slight increase in total biomass production, across all study species and for the high-productive species *A. elatius* and *D. glomerata*, while plants of the low-productive species *A. pratensis* and *P. trivialis* had a similar total biomass production as in the control (Fig. 4c, f). Root-shoot ratios were as low as in fertilized plants, across all species and in *P. trivialis* (Fig. 4c, f). Plants of *A. elatius* and *D. glomerata* increased root-shoot ratios, similar to plants under drought (Fig. 4f). In contrast, *A.*

pratensis strongly decreased root-shoot ratios resulting in the lowest values compared to the other treatments (Fig. 4f).

Plant traits and pathogen infestation

Across all study species, drought did not significantly alter growth height, but nitrogen input increased height (Appendix S2: Fig. S1). When treated with both global change drivers, drought canceled out the positive nitrogen input effect, leading to similar height of plants treated with both global change drivers and control plants. Further, drought and nitrogen input increased shoot nitrogen concentrations and leaf greenness, with additive effects when both global change drivers were applied together (Appendix S2: Fig. S1). Drought did not influence LDMC and SLA, while nitrogen input decreased LDMC and increased SLA (Appendix S2: Fig. S2). When treated with both global change drivers, drought mitigated the decrease of LDMC under nitrogen input, while the increase of SLA under nitrogen input did not change with drought (Appendix S2: Fig. S2). Stomatal conductance was increased, when plants were treated with drought, but did not change when fertilized irrespective of the drought treatment (Appendix S2: Fig. S2). In terms of root traits, we found a decrease of RLD under drought (irrespective of fertilization) and an increase in root diameter under nitrogen input (irrespective of drought; Appendix S2: Fig. S3). Results of species-specific trait expression changes under global change drivers can be found in Figure 3b-d and Appendix S2.

In *D. glomerata*, mildew infestation remained unchanged when treated with drought, but increased with nitrogen input. When treated with both global change drivers, mildew infestation was as high as in fertilized plants (Fig. 3b-d; Appendix S2: Fig. S4). In *P. trivialis*, mildew infestation was increased under drought and when fertilized, while the combination of both global change drivers led to the highest mildew infestation (Fig. 3b-d; Appendix S2: Fig. S4).

Hypothesis 3: offspring of plants selected at different diversity and grown in different soil (high vs. low diversity, home vs. away) respond differently to global change drivers

Biomass production

Plants from two- and six-species communities did not differ in shoot biomass production when treated with drought, but plants from six-species communities treated with drought tended to produce more root biomass than plants from two-species communities across all study species (Table 3; Fig. 5a, d, g). At species-level, we found no significant effects of legacy treatments under drought (Fig. 3b; Appendix S3: Table S8-S11).

When plants were fertilized, we found an impact of plant history across all study species: fertilized plants originated from six-species communities had a higher root and total biomass production than plants from two-species communities (Table 3; Fig. 5a, g). This was also found in *D. glomerata* plants, which tended to produce more shoot and total biomass when originated from six-species communities (Fig. 3c; Appendix S3: Table S10). In *A. elatius*, total biomass production of fertilized plants was significantly higher (and shoot biomass marginally significantly higher), when plants were grown in home and away-same than in away-different soil (Fig. 3c; Appendix S3: Table S8). In *A. pratensis*, fertilized plants grown in two-species community soil tended to produce more total biomass than in six-species community soil (Fig. 3c; Appendix S3: Table S9), while fertilized *P. trivialis* showed no significant differences (Fig. 3c; Appendix S3: Table S11).

When plants were treated with both global change drivers, the effects of nitrogen input were cancelled out or changed by drought, i.e. there was no significant impact of legacy treatments on biomass production across all study species and for *A. elatius* (Table 3; Fig. 3d; Appendix S3: Table S8). In *D. glomerata*, the significant influence of plant history disappeared, but plants in home and away-different soil showed higher root-shoot ratios than plants in away-same soil (Fig. 3d; Appendix S3: Table S10). Plants of *P. trivialis* treated with both global change drivers tended to have higher root biomass and root-shoot ratios when grown in home than in away-same soil (Fig. 3d; Appendix S3: Table S11). In contrast to the overall trend, *A. pratensis* was the only species which showed a similar response to nitrogen input and treatment with both global change drivers: the biomass production was higher in two- than in six-species community soil (for both global change drivers: significant higher root biomass and root-shoot ratios; Fig. 3d; Appendix S3: Table S9).

Plant traits and pathogen infestation

Shoot nitrogen concentration was not influenced by plant or soil history when treated with drought, but fertilized plants in six-species soil had higher shoot nitrogen concentrations than in two-species soil (soil history effect; Appendix S3: Table S1; Fig. S1). Moreover, fertilized plants had lower shoot nitrogen concentrations in home than in away-different soil (soil treatment effect; Appendix S3: Table S1; Fig. S1). When plants were treated with both global change drivers, the nitrogen input effect on soil history was cancelled out by drought, while the impact of soil treatment did not: plants in home soil still had lower shoot nitrogen concentration than plants in away soil (Appendix S3: Table S1; Fig. S1). Other plant traits (growth height, leaf greenness, LDMC, SLA, stomatal conductance, root traits) did not significantly differ depending on legacy treatments when plants were treated with nitrogen or drought (Appendix S3: Table S1). At species level, we found a large number of different responses depending on legacy treatments and type of global change driver, which can be found in Figure 3b-d and Appendix S3.

Mildew infestation of *D. glomerata* plants exposed to drought was higher in home than in away soil, while this drought effect was cancelled out by nitrogen input (Appendix S3: Table S6). Mildew infestation of *P. trivialis* plants was not significantly influenced by legacy treatments, neither with nor without global change drivers (Appendix S3: Table S6).

Tables

Table 1 Summary list of response variables and experimental factors of the common garden experiment

Variable	Abbreviation	Unit	Description
Response variables			
Biomass production			
Total biomass	Total Bm	g_{total}	Shoot and root biomass per pot
Shoot mass	Shoot Bm	g_{shoot}	Shoot biomass per pot
Root mass	Root Bm	g_{root}	Root biomass per pot
Root-shoot ratio	-	$g_{root}\ g_{shoot}^{-1}$	Root biomass divided by shoot biomass per pot
Aboveground traits			
Growth height	-	cm	Stretched shoot length of longest vegetative shoot[a]
Shoot nitrogen concentration	N_{Shoot}	mg N g_{shoot}^{-1}	Nitrogen mass per dry shoot mass
Leaf greenness	-	-	Unitless estimate of leaf chlorophyll concentration[a]
Specific leaf area	SLA	$mm_{leaf}^{2}\ mg_{leaf}^{-1}$	Leaf area per dry leaf mass[a]
Leaf dry matter content	LDMC	$mg_{leaf}\ g_{leaf}^{-1}$	Dry leaf mass per water-saturated fresh leaf mass[a]
Stomatal conductance	g_s	mmol $m^{-2}\ s^{-1}$	Stomatal conductance per leaf area[a]
Belowground traits			
Root diameter	Dia	mm	Average root diameter of the root subsample
Specific root length	SRL	$m_{root}\ g_{root}^{-1}$	Root length per dry root biomass (subsample)
Root length density	RLD	$cm_{root}\ cm_{soil}^{-3}$	Root length (extrapolated) per soil volume (pot)
Pathogen infestation	-	%	Percentage of infested leaf area (estimated)[a]
Experimental factors			
Species identity	Species ID	-	Study species
Legacy treatments			
Plant history	PH	-	Species richness of the plant community, where the seeds were collected – two or six plant species
Soil history	SH	-	Species richness of plant community, where the soil for inoculation was taken – two or six plant species
Soil treatment	ST	-	Origin of seed and soil in one pot: - same plot origin = home soil treatment - different plot origin, but same species richness = away-same soil treatment - different plot origin, different species richness = away-different soil treatment
Global change driver treatments	global change driver / global change / GC		
Drought treatment	Drought / D	-	30% instead of 60% water saturation
Nitrogen input treatment	Nitrogen input / N	-	Fertilization with NH_3NO_4 (8x 95 mg)

[a] averaged per pot

Table 2 Summary of mixed-effect model analyses testing the effects of species identity (N = 4), legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input), and their interactions on plant performance (total biomass, shoot biomass, root biomass). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

	Total biomass			Shoot biomass			Root biomass		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species identity (ID)	3	73.25	**<0.001**	3	80.17	**<0.001**	3	121.30	**<0.001**
Plant history	1	3.48	*0.062*	1	1.36	0.244	1	3.40	*0.065*
Soil history	1	0.01	0.915	1	0.04	0.851	1	0.49	0.484
Soil treatment	2	2.17	0.338	2	1.20	0.548	2	3.66	0.161
Drought (D)	1	83.05	**<0.001**	1	110.26	**<0.001**	1	2.81	*0.094*
Nitrogen input (N)	1	257.26	**<0.001**	1	425.93	**<0.001**	1	15.89	**<0.001**
Species ID x Plant history	3	0.71	0.872	3	1.77	0.621	3	0.63	0.890
Species ID x Soil history	3	1.68	0.642	3	0.18	0.980	3	3.64	0.303
Species ID x Soil treatment	6	4.29	0.638	6	6.64	0.355	6	2.30	0.891
Species ID x D	3	52.00	**<0.001**	3	43.11	**<0.001**	3	98.61	**<0.001**
Species ID x N	3	30.46	**<0.001**	3	33.73	**<0.001**	3	18.28	**<0.001**
D x N	1	35.27	**<0.001**	1	27.47	**<0.001**	1	10.90	**0.001**
Species ID x Plant history x D	4	0.92	0.922	4	4.42	0.353	4	0.72	0.948
Species ID x Soil history x D	4	1.17	0.883	4	5.33	0.255	4	0.54	0.969
Species ID x Soil treatment x D	8	2.81	0.946	8	4.78	0.781	8	3.30	0.914
Species ID x Plant history x N	4	2.66	0.617	4	5.75	0.219	4	1.69	0.792
Species ID x Soil history x N	4	6.59	0.159	4	3.47	0.482	4	5.26	0.262
Species ID x Soil treatment x N	8	9.35	0.314	8	4.62	0.797	8	15.48	*0.050*
Species ID x Plant history x D x N	4	14.85	**0.005**	4	27.25	**<0.001**	4	12.61	**0.013**
Species ID x Soil history x D x N	4	13.14	**0.011**	4	14.39	**0.006**	4	11.81	**0.019**
Species ID x Soil treatment x D x N	8	6.19	0.626	8	7.91	0.442	8	4.81	0.778

Table 3 Summary of mixed-effect model analyses testing the effects of species identity (N = 4), legacy treatments (plant history, soil history, soil treatment), and their interactions on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio), when non-treated (control) or treated with global change drivers (drought, nitrogen input, drought and nitrogen input [D x N]). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

	Total biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	57.93	**<0.001**	3	37.43	**<0.001**	3	60.10	**<0.001**	3	27.83	**<0.001**
Plant history (PH)	1	0.04	0.840	1	2.08	0.149	1	4.86	**0.027**	1	1.17	0.280
Soil history (SH)	1	2.60	0.107	1	0.44	0.507	1	1.15	0.283	1	0.10	0.756
Soil treatment (ST)	2	0.80	0.670	2	0.46	0.795	2	3.78	0.151	2	3.28	0.194
Species ID x PH	3	1.05	0.790	3	3.44	0.328	3	1.37	0.712	3	0.04	0.998
Species ID x SH	3	3.06	0.382	3	2.48	0.478	3	1.61	0.657	3	2.48	0.479
Species ID x ST	6	3.44	0.752	6	3.55	0.737	6	4.91	0.555	6	4.04	0.672

	Shoot biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	45.01	**<0.001**	3	47.33	**<0.001**	3	64.80	**<0.001**	3	43.66	**<0.001**
Plant history (PH)	1	0.03	0.859	1	0.45	0.502	1	2.56	0.110	1	0.77	0.381
Soil history (SH)	1	1.57	0.211	1	0.11	0.743	1	1.97	0.161	1	0.06	0.799
Soil treatment (ST)	2	0.24	0.886	2	2.51	0.286	2	4.39	0.112	2	1.91	0.385
Species ID x PH	3	0.18	0.980	3	6.79	*0.079*	3	4.34	0.227	3	0.60	0.900
Species ID x SH	3	7.50	*0.058*	3	2.08	0.556	3	0.06	0.996	3	0.67	0.881
Species ID x ST	6	6.46	0.374	6	2.67	0.849	6	7.67	0.263	6	2.27	0.893

	Root biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	107.40	**<0.001**	3	93.04	**<0.001**	3	101.11	**<0.001**	3	81.40	**<0.001**
Plant history (PH)	1	<0.01	0.957	1	2.79	*0.095*	1	3.34	*0.068*	1	1.20	0.274
Soil history (SH)	1	2.79	*0.095*	1	1.27	0.259	1	0.05	0.828	1	0.11	0.742
Soil treatment (ST)	2	0.60	0.740	2	0.74	0.691	2	2.08	0.354	2	4.40	0.111
Species ID x PH	3	2.74	0.434	3	1.34	0.720	3	0.78	0.855	3	0.76	0.860
Species ID x SH	3	3.68	0.299	3	3.00	0.391	3	3.11	0.375	3	4.02	0.259
Species ID x ST	6	7.55	0.273	6	5.43	0.490	6	3.05	0.803	6	9.25	0.160

Figures

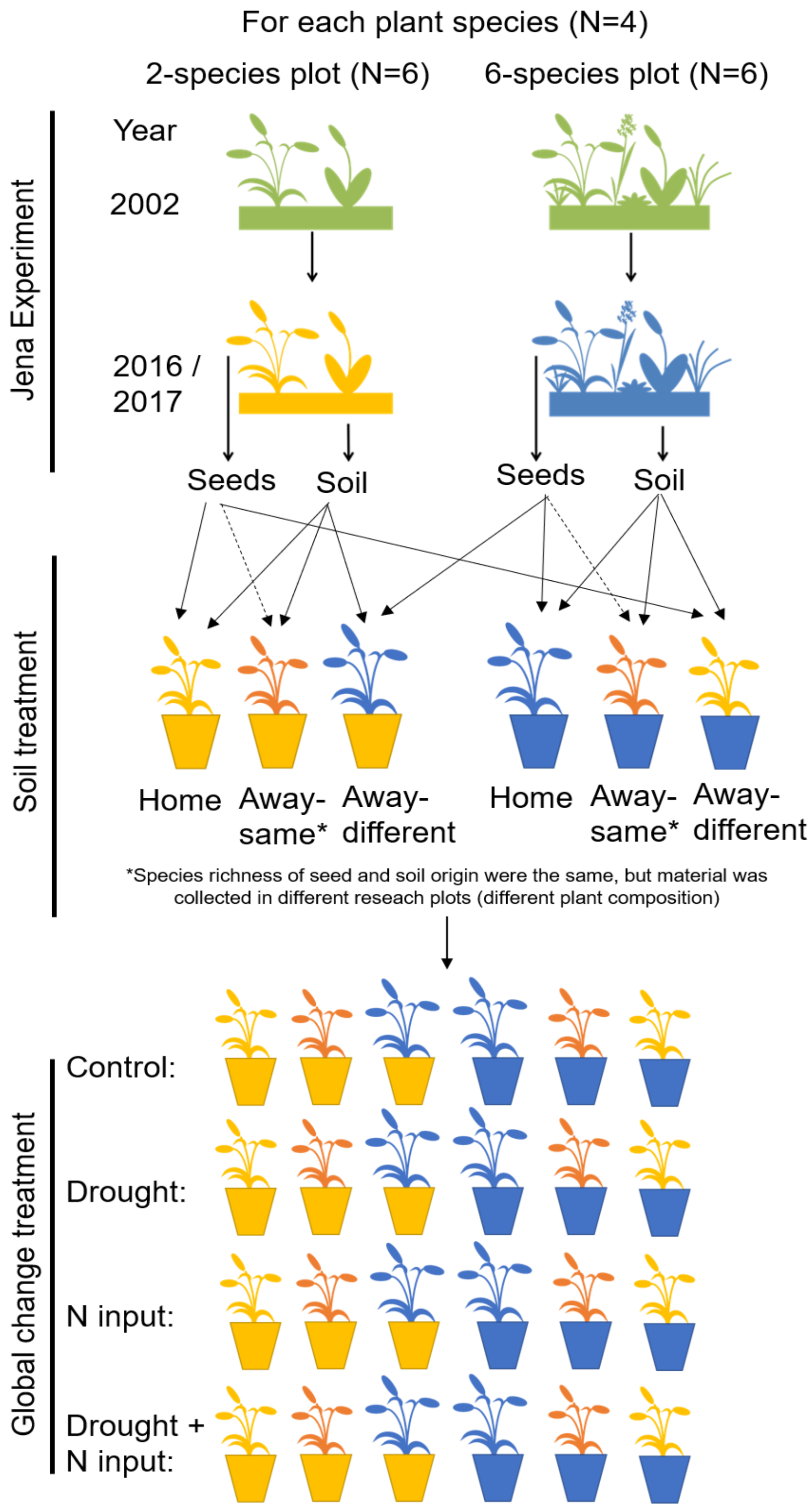

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Figure 1 Overview of experimental design. In 2016, ripe seeds of four grass species were collected in two- and six-species plots of the Dominance Experiment (Jena Experiment), stored in a freezer and allowed to germinate in spring 2017. After germination, soil samples were collected from the plots and mixed with sterilized background soil (5% + 95%), filled in pots and planted with two seedlings (12 pot replicates per plot). In four pots per plot, plant and soil had the same plot origin (home soil); in four pots, species richness of plant and soil origin were the same, but plant species composition was different (away-same soil) and in four pots, species richness of plant and soil origin were different (= different origin of plant and soil; away-different soil; total Nr_{pots} = 576). Plants were exposed to global change drivers: drought, nitrogen input, or the combination of drought and nitrogen input, or were not treated (control).

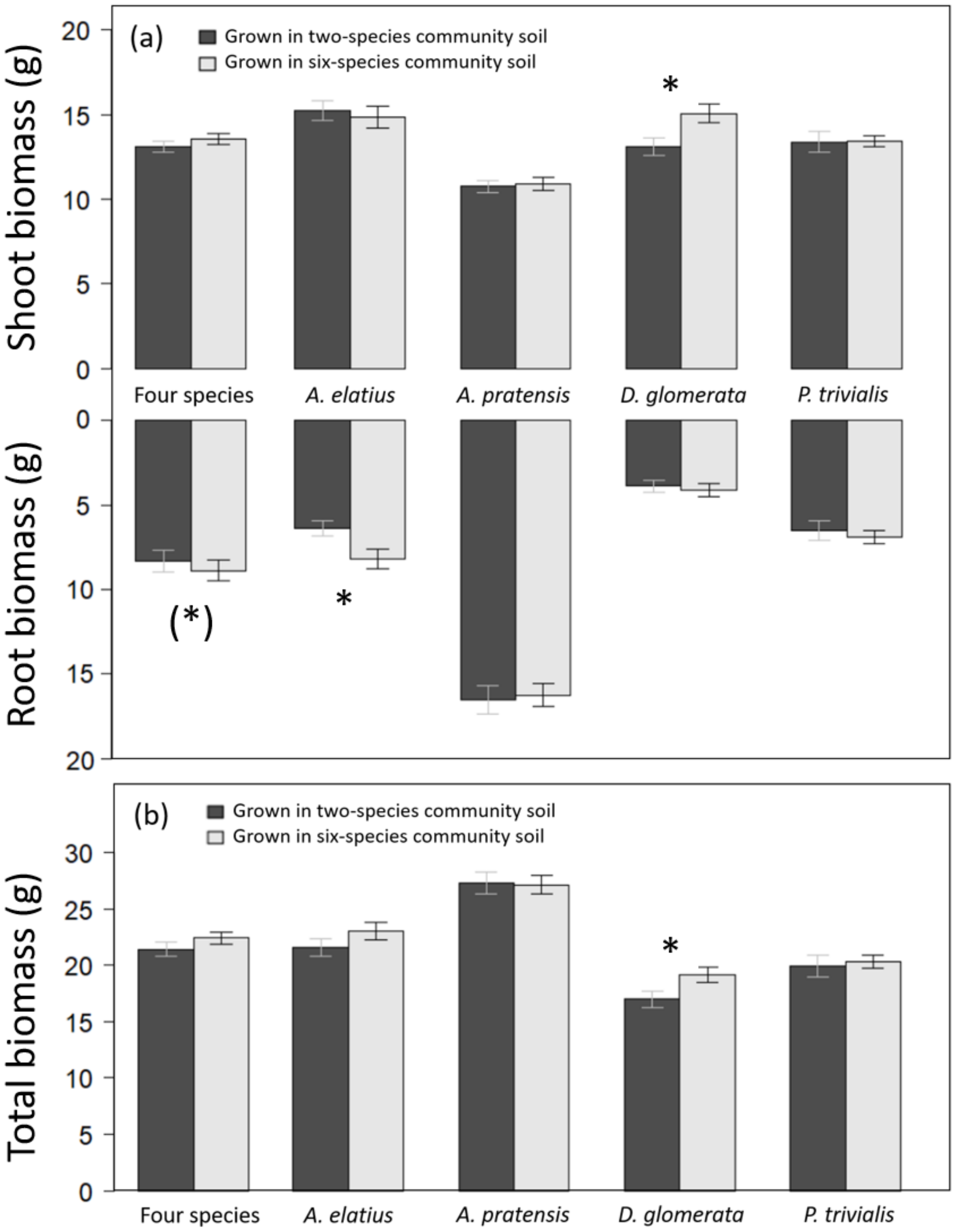

Figure 2 Shoot and root biomass production (a), and total biomass production (b) of plants grown either in soil originated from two-species or six-species communities across all four study species and separately for each species. Bars show mean values (± 1 SE); stars above bars indicate significant differences ($P < 0.05$), stars in brackets indicate marginally significant differences ($P < 0.1$).

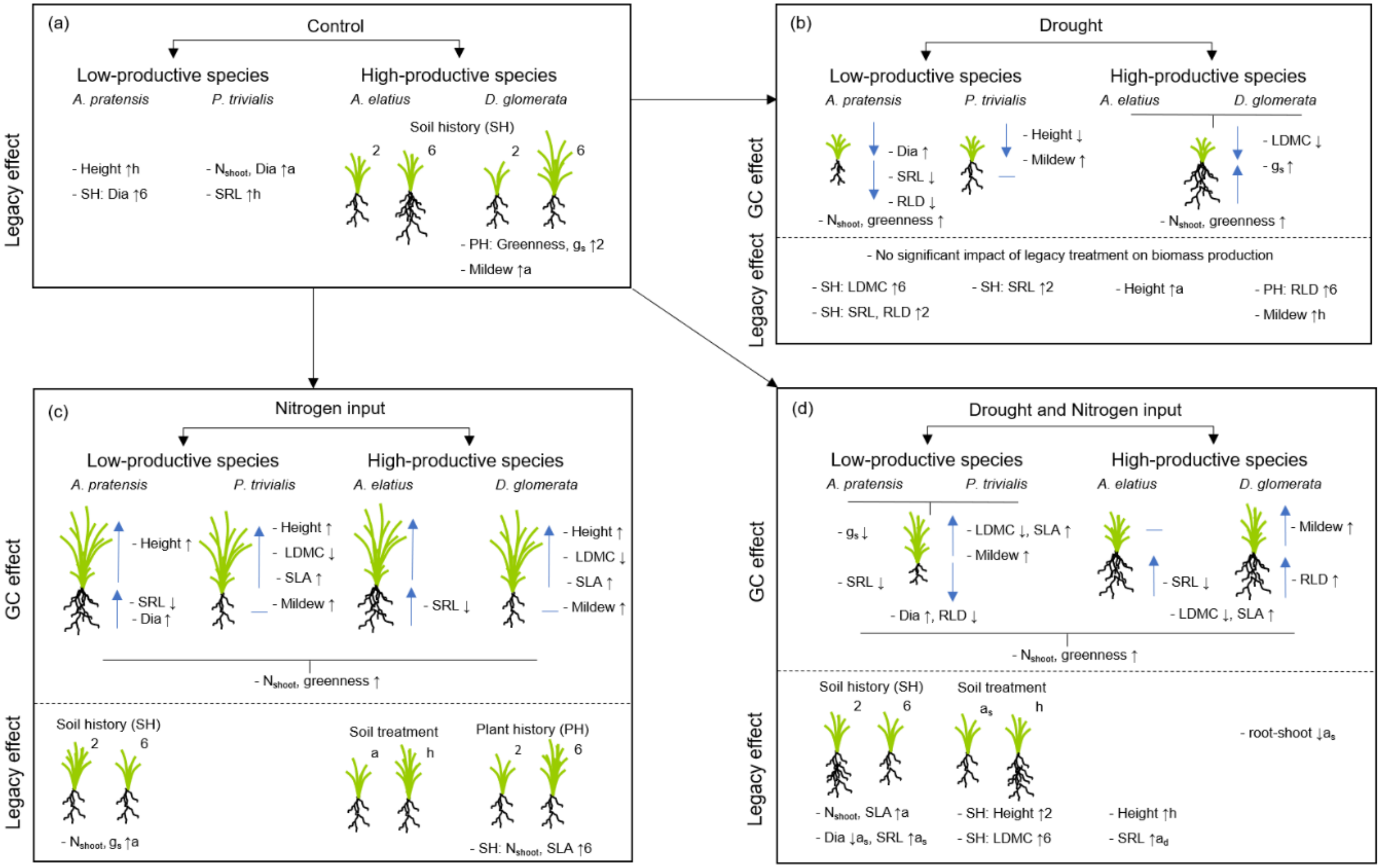

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Figure 3 Schematic overview of the results of the common garden experiment testing how plants with a different origin (plant history) or grown in different soil (soil history, soil treatment) differ in performance and trait expression (a) and respond to global change drivers like drought (b), nitrogen input (c), and the combination of both (c). Illustrated is the impact of legacy treatments (= "legacy effect") and global change treatments (= "global change effect") on shoot and root biomass production as well as on plant traits (growth height ("Height"), shoot nitrogen concentration ("N_{shoot}"), leaf greenness ("Greenness"), leaf dry matter content ("LDMC"), specific leaf area ("SLA"), stomatal conductance ("g_s"), mildew infestation ("Mildew"), root diameter ("Dia"), specific root length ("SRL"), root length density ("RLD")) of the four study species. For legacy effects, schematic illustrations of plants indicate differences in shoot and/or root biomass, when originated from two-species ("2") or six-species ("6") communities (= plant history (PH)), when grown in two-species ("2") or six-species ("6") community soil (= soil history (SH)), or when grown in away ("a") or home ("h") soil (= soil treatment; "a_s" = away-same soil). Arrows behind traits (for legacy effects) indicate, in which treatment group the value was significant higher (arrow up) or lower (arrow down), e.g. "- SH: SLA ↑6" indicate that SLA in plants grown in six-species soil was higher than in two-species soil and "- LDMC ↑h" indicate that LDMC was higher in plants grown in home than in away soil. For global change effects, schematic illustrations of plants indicate whether shoot and/or root biomass of plants increased (blue arrow up) or decreased (blue arrow down) due to the impact of the respective global change driver (blue horizontal line indicate no change). Arrows behind traits (for global change effects) indicate and increase (arrow up) or decrease (arrow down) of the trait value due to the impact of the respective global change driver.

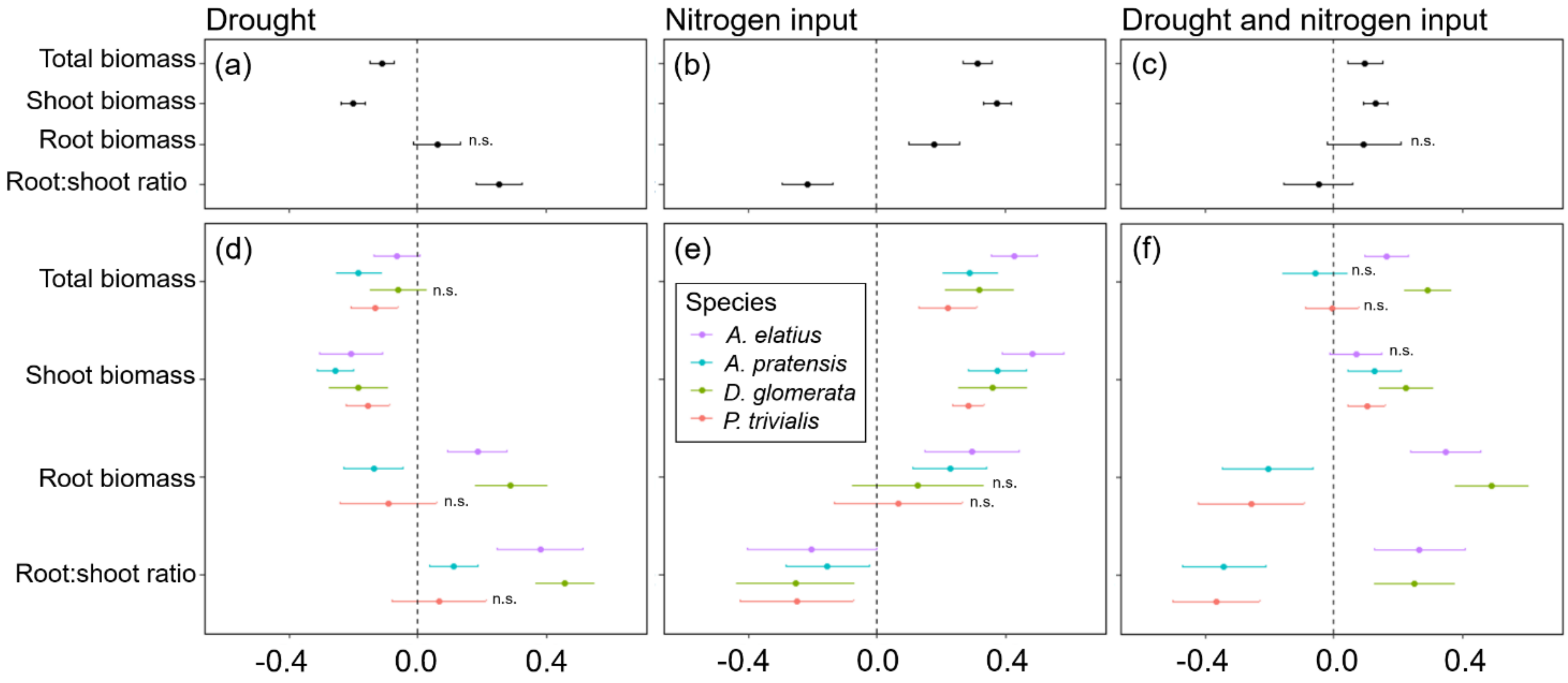

Figure 4 Response of plants treated with drought, nitrogen input, or a combination of both relative to non-treated plants (control) for total biomass, shoot biomass, root biomass, and root-shoot ratio across four study species (a-c) and separately for each species (d-f). Points are means and error bars are standard deviation. No symbol indicates significant differences between plants treated with global change driver and control plants, “n.s.” indicate no significant difference.

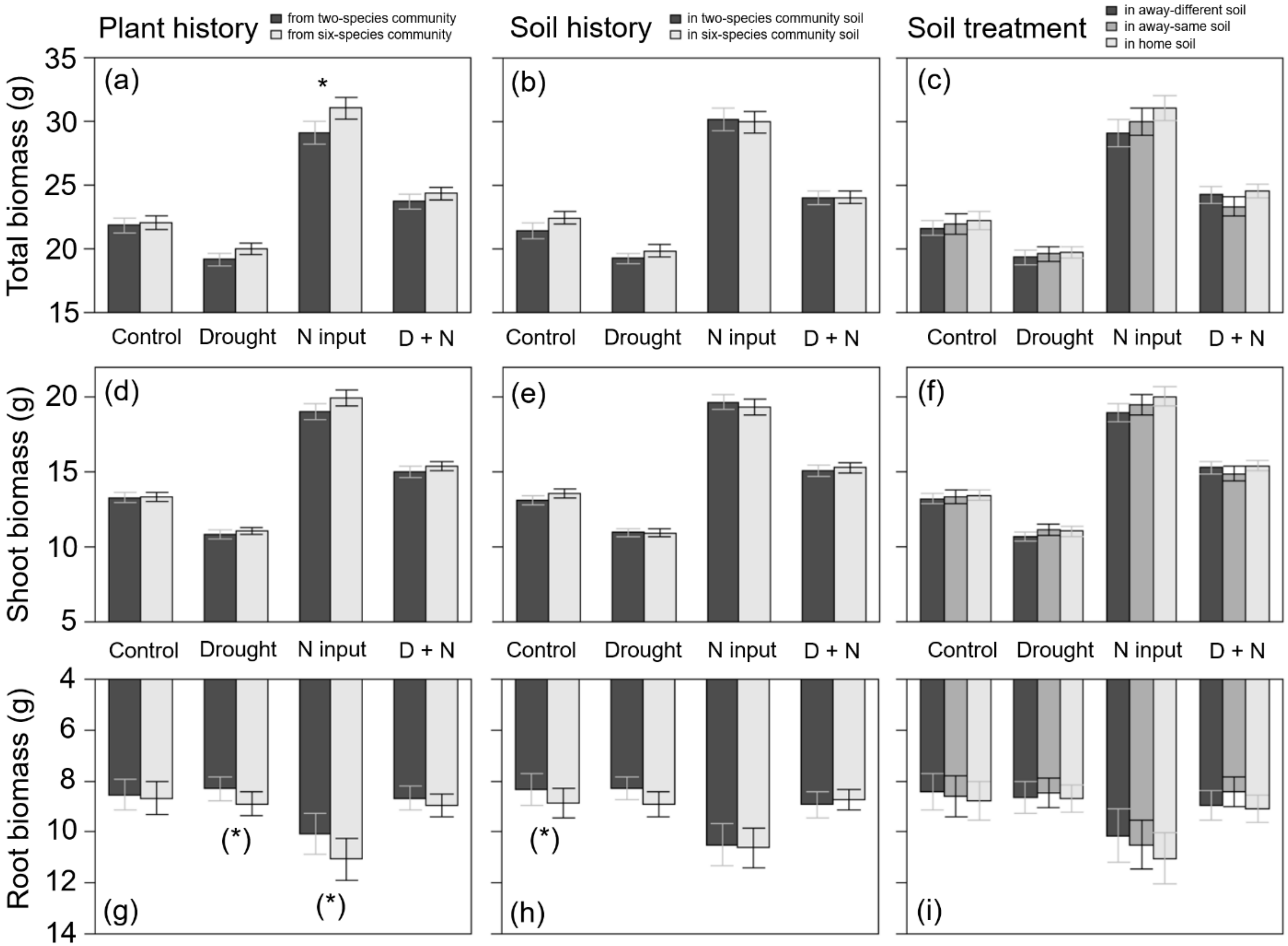

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Figure 5 Total biomass (a-c), shoot biomass (d-f), and root biomass (g-i) of plants (across all four study species) originated from two- or six-species communities (plant history; a, d, g); grown in soil originated from two-species or six-species communities (soil history; b, e, h); or grown in home, away-same or away-different soil (soil treatment; c, f, i) and were either non-treated (control) or treated with drought, nitrogen input (N input) or a combination of both (D + N). Bars show mean values (± 1 SE); stars above bars indicate significant differences ($P < 0.05$), stars in brackets indicate marginally significant differences ($P < 0.1$).

Discussion

Hypothesis 1: offspring of plants selected at different diversity and grown in different soil (high vs. low diversity, home vs. away) show differences in productivity and trait expression

Our findings that *A. elatius* and *D. glomerata* plants in soil of high-diversity communities produce more biomass than in soil of low-diversity communities are in line with several greenhouse studies showing that soil conditioned by multiple plant species has a more positive impact on plant growth than soil conditioned by only one or two plant species (Guerrero-Ramírez et al. 2019; Yang et al. 2015). Plants probably suffered more from pathogens when grown in soil of low-diversity communities and/or benefitted more from interactions with soil mutualists in soil of high-diversity communities (Eisenhauer et al. 2019; Guerrero-Ramírez et al. 2019; Schnitzer et al. 2011). Interestingly, this soil legacy effect was only found in *A. elatius* and *D. glomerata*, which were both highly-productive species in the long-term field experiment. In contrast, the low-productive species *A. pratensis* and *P. trivialis* showed no significant difference when grown in differently conditioned soils. This is an indication that *A. elatius* and *D. glomerata* interact and/or benefit more, and *A. pratensis* and *P. trivialis* less, with soil mutualists, which are more abundant at high plant diversity, explaining our findings and the species-specific performance in the field experiment.

In contrast to biomass production, we did not find any significant influence of soil history on plant trait expression of *A. elatius* and D. *glomerata*. Nevertheless, we detected some other legacy treatment effects on plant trait expression, which was also found in related studies (van Moorsel et al. 2018a; van Moorsel et al. 2018b). The impact of soil history on root diameter of *A. pratensis*, and the impact of soil treatment (home/away) on the growth height of *A. pratensis*, on shoot nitrogen concentrations and root traits of *P. trivialis*, and on mildew infestation of *D. glomerata* indicate that plant-soil interactions influencing growth, defense, and resource use strategies of plants (Xi et al. 2021), while this impact is species-specific. Moreover, *D. glomerata* plants had higher leaf greenness and stomatal conductance, when originated from low-diversity than from high-diversity plant communities. This could be an adaptation to higher light availability and lower soil moisture in low-diversity communities due to lower shading (Bachmann et al. 2018; Fischer et al. 2019; Lorentzen et al. 2008).

Hypothesis 2: global change drivers have a strong impact on the productivity and trait expression of plants.

In accordance with our second hypothesis, we found that drought reduced total biomass production. This was mainly caused by a loss of shoot biomass, while drought differently affected root biomass production of the studied grass species. Individuals of *A. elatius* and *D. glomerata* increased in root biomass at the expense of shoot biomass, leading to higher root-shoot ratio under drought. This is a commonly observed strategy to avoid dehydration, which enables plants to tap water from deeper soil layers (in the field) and at the same time minimizes the water loss caused by transpiration (Eziz et al. 2017). In contrast, the low-productive species either decreased instead of increased root biomass (*A. pratensis*) or did not change root biomass production (*P. trivialis*) under drought. Interestingly, the low-productive species had a three times higher loss of total biomass under drought (*A. pratensis*: -17.1%; *P. trivialis*: -15.3%) than the highly-productive species (*A. elatius*: -6.4%; *D. glomerata*: -5.7%, no significant loss of total biomass in *D. glomerata*). Presumably, the drought resistance strategy of *A. elatius* and *D. glomerata* is more effective, which is possibly a competitive advantage under the field conditions of the Jena Experiment, explaining the dominance of these species.

The influence of drought on the expression of plant traits was plant species-specific, except for shoot nitrogen concentrations and leaf greenness, which increased under drought in three species (except *P. trivialis*). Similar results were found in previous studies (Kocoń and Staniak 2014; Rolando et al. 2015) and indicate a general strategy against drought stress: plants decrease the cell density of shoot tissues, in line with the reduction of shoot biomass to minimize the water loss, leading to an increase in the concentration of nitrogen compounds and chlorophyll (strong correlation between leaf greenness and chlorophyll concentration were found in Bachmann et al., 2018). At species-level, the low-productive species showed trait expression changes similar to biomass loss under drought, while the highly-productive species *D. glomerata* decreased in LDMC and increased in stomatal conductance, which is contrary to recent studies showing the opposite strategy to resist drought (high LDMC, low stomatal conductance) (Bristiel et al. 2018; Jaballah et al. 2008; Lozano et al. 2020). The results may differ because *D. glomerata* in our study was infested by the mildew *Blumeria graminis*, which may have changed the leaf structure, and thus also trait expression changes under drought.

Furthermore, our second hypothesis was confirmed by showing that nitrogen input increased biomass production. At species-level, shoot biomass was increased in all four species, while root biomass was enhanced only in *A. elatius* and *A. pratensis*. In *D. glomerata* and *P. trivialis*, there was also a slight, but non-significant increase in root biomass. Both species showed a strong increase in mildew infestation when fertilized. This confirms the nitrogen-disease hypothesis indicating that nitrogen supply increases infection severity by altering leaf properties and resources for pathogens (Dordas 2008). In *D. glomerata* and *P. trivialis*, severe infestation by powdery mildew *Blumeria graminis* may have led to a decrease in rates of net photosynthesis (Hibberd et al. 1996; Mandal et al. 2009), so that the reduced amount of energy was mainly invested in shoot biomass, e.g. for a higher leaf turnover, and less in root biomass.

We found consistent changes in plant trait expression over all four species in response to nitrogen input: growth height (except *A. elatius*), shoot nitrogen concentrations, and leaf greenness increased in all four species when fertilized, confirming an earlier study by Siebenkäs et al. (2015). Further nitrogen-induced changes in trait expression were likely affected by mildew infestation: the highly-infested species (*D. glomerata, P. trivialis*) showed lower LDMC and higher SLA, while LDMC and SLA of non-infested species did not change. Probably, *D. glomerata* and *P. trivialis* plants responded to the increase in mildew infestation with a change in the leaf architecture (Cappelli et al. 2020), which could enable plants to turn over their leaves more quickly and thus produce constantly new and unaffected leaves. With regard to root traits, the non-infested species decreased in specific root length (and *A. pratensis* also in root diameter), while root traits remained unchanged in the highly-infested species. The decrease in SRL and increase in diameter (i.e. thicker and shorter roots) in combination with the increase in root biomass of the fertilized *A. elatius* and *A. pratensis* plants indicate that these plants changed the root architecture building fewer fine roots when nutrient availability is enhanced, which is in line with similar research (Siebenkäs et al. 2015).

Finally, we hypothesized that global change drivers cancel out each other's impact when applied together. This was true for the low-productive species *A. pratensis* and *P. trivialis*, which did not change in total biomass production compared to control plants as also found in other research (Carlsson et al. 2017). However, the strong decrease in root-shoot ratios indicates that *A. pratensis* and *P. trivialis* plants changed their growth strategies. Interestingly, the high-productive species *A. elatius* and *D. glomerata* slightly increased in total biomass, which is mainly explainable by the additive positive impact of drought and nitrogen input on root biomass, resulting in increased root-shoot ratios. Obviously, dominant (or highly-productive) species in our study benefitted more strongly from the combined application of the global change drivers in comparison to subordinate (or low-productive) species. Assuming that dry periods are becoming more frequent (Ruosteenoja et al. 2018) and nitrogen deposition may steadily rise (Reay et al. 2008), our results suggest that competitive interactions change under the impact of multiple global change drivers, and subordinate species may become more severely threatened by extinction (Pugnaire et al. 2019).

Moreover, our results show that the combined effects of the two global change drivers on plant trait expression may differ from the effect of drought or nitrogen input alone, with strong negative effects for some plant species (e.g. highest mildew infestation of *P. trivialis* under combined impact of global change drivers). This suggests that plants change in physiology and morphology and thus in their response to global change, when a combined impact becomes more frequent, with an unknown influence on community composition and ecosystem functioning in the long term. This finding underlines the need for studies investigating multiple, interacting global change drivers (Rillig et al. 2019; Thakur et al. 2018).

Hypothesis 3: offspring of plants selected at different diversity and grown in different soil (high vs. low diversity, home vs. away) respond differently to global change drivers

The soil history effect, i.e. the beneficial effect of soil biota from high-diversity plant communities on biomass production of control plants, disappeared in treatments with global change drivers, which may be explainable by a change in soil community structure under drought (Kaisermann et al. 2017; Pugnaire et al. 2019) and/or nitrogen input (Wei et al. 2018). In line with our result, similar studies have shown that drought (Fry et al. 2018; Wilschut and van Kleunen 2021) and nitrogen input (in ’t Zandt et al. 2019) can interrupt or change plant-soil interactions. As a result, the beneficial effect of soil biota from high-diversity communities in *A. elatius* and *D. glomerata* could have been lost due to the reduction of soil mutualists (Yang et al. 2021) and/or an increase in soil-borne pathogens caused by global change drivers (Delgado-Baquerizo et al. 2020; Tylianakis et al. 2008; van der Putten et al. 2016).

Next to soil history, we also found altered plant responses to global change drivers when plants originated from low- or high-diversity communities (plant history). When treated with drought, there was no significant difference, but nitrogen input had a more positive impact on plants originated from high-diversity than from low-diversity communities. One possible explanation is that plants at high diversity were selected for greater niche complementarity (Zuppinger-Dingley et al. 2014), while plants at low diversity were selected for increased defense against species-specific pathogens (Eisenhauer et al. 2019), that are often accumulate in low-diversity environments (Eisenhauer et al. 2012). Consequently, the offspring of individuals originated from high-diversity communities may be more efficient in allocating additional resources in increased growth, explaining our results. Interestingly, we did not find any significant plant history effect in plants treated with both global change drivers, indicating that drought had a strong impact on the growth strategy of the plants and can counteract positive diversity effects.

Finally, we found that plants in home and away soil may respond differently to global change drivers; however, this was only true for the high-productive species *A. elatius*: plants benefitted more from fertilization in home and away-same than in away-different soil. The home advantage supports the idea that a decrease of plant diversity can lead to changes in plant-soil interactions and thus to differences in eco-evolutionary feedbacks at low and high diversity (terHorst and Zee 2016). With our data in hand, we cannot determine the exact reason why we found the home advantage under fertilization but not under control conditions; however, our results show that plants may respond differently to global change drivers depending on the soil community with which they interact.

Similar to the biomass production results, almost all differences in trait expression found in control plants disappeared when treated with global change drivers. Instead, many other changes in trait expression occurred depending on the type of global change driver treatment and plant species identity. Taken together, these results indicate that mainly soil biota (soil history and soil treatment) and only to a lesser extent plant history play an important role in the expression of traits under the influence of global change drivers. This suggests that the soil biota composition is strongly associated with the physiology and morphology of the plants. Therefore, shifts in soil biota composition due to plant species loss and/or global change driver impact can have strong effects on the response of plants to global change, which could further accelerate plant community change and species loss (Pugnaire et al. 2019; Yang et al. 2021).

Conclusion

In the present study, we showed for the first time that offspring of plants selected at low and high plant diversity differently respond to global change and that plant-soil interactions play a significant role in this process. This suggests that not only external influences (i.e. global change drivers), but related changes within the community (i.e. changes in eco-evolutionary feedbacks) could promote a further loss of species and thus an acceleration of global change effects. To confirm this assumption, future research should test the long-term influence of global change drivers on soil biota and plants selected at low and high diversity under more realistic conditions, such as plants growing in communities under field conditions.

Materials and methods

The Jena Experiment

Seed and soil material for our common garden experiment was collected from a long-term biodiversity experiment, the Jena Experiment, which is located in the floodplain of the Saale river near Jena (Thuringia, Germany, 50° 55′N, 11° 35′E, 130 m a.s.l.) (Roscher et al. 2004; Weisser et al. 2017). Before the establishment of the Jena Experiment in 2002, the site was a highly fertilized arable field, which had been used for growing wheat and vegetables from the early 1960s until 2000. Mean annual air temperature recorded from 2007 to 2016 at the experimental site (Weather Station Jena-Saaleaue, Max-Planck-Institute for Biogeochemistry Jena, https://www.bglobal change-jena.mpg.de/wetter/) was 9.7°C, and mean annual precipitation was 587 mm. The soil of the study site is a Eutric Fluvisol, whereas soil texture changes from sandy loam to silty clay with increasing distance from the river Saale. Thus, four blocks were arranged parallel to the riverside (Roscher et al., 2004).

Material for our study was collected in a sub-experiment of the Jena Experiment, the so-called Dominance Experiment. The species pool of this experiment included nine species, which often reach dominance in Central European mesophilic grasslands of the Arrhenatherion type (Ellenberg 1988): five grasses, two legumes, and two herbs. Sown plant species richness levels were 1, 2, 3, 4, 6, and 9 species. Each species occurred eight times in the different compositions of each species-richness level. Moreover, each possible two-species combination was present with equal frequency at each species-richness level of the mixtures (i.e. 2-9 species; more information about the design can be found in Roscher et al. 2004). In May 2002, seeds were sown with a density of 1000 viable seeds per m^2. Seeds from all species were purchased from a commercial supplier (Rieger-Hoffman GmBH, Blaufelden-Raboldshause, Germany). From 2002 to 2009, plants were grown in plots of 3.5 × 3.5 m; from 2010 onwards, plot size was reduced to 1 × 1 m. Plots were mown every year in June and September and mown plant material was removed. All plots were regularly weeded and never fertilized.

Seed collection, selection of study species, and experimental plots

In summer 2016, we collected seed material from the nine species in all Dominance Experiment plots (as bulk sample per species and plot) and stored them in a freezer (at -20°C) until further use. We chose four grass species (*Alopecurus pratensis* L., *Arrhenatherum elatius* (L.) P. Beauv. ex J. Presl et C. Presl, *Dactylis glomerata* L., *Poa trivialis* L.) as study species. Furthermore, we selected 12 plots per species (six two-species and six six-species plots, i.e. 48 plots in total), where sufficient seed material was available. The selected plots were evenly distributed in the four blocks of the experiment (Roscher et al. 2004). The study species differed strongly in their biomass production in the Dominance Experiment plots. In the two-species plots, all four species showed a high biomass production; however, in the six-species plots, only *A. elatius* and *D. glomerata* were highly-productive, while *A. pratensis* and *P. trivialis* showed intermediate levels and decreased in biomass production over the years (Clark et al. 2019; Roscher et al. 2007). For simplification, from here onwards, *A. elatius* and *D. glomerata* are referred to as “highly-productive” species, while *A. pratensis* and *P. trivialis* are referred to as “low-productive” species.

Preparation of background substrate and study plants

For the pot substrate, we used a sterilized sand-soil mix (= background substrate), which was then inoculated with fresh living soil (5% of the total substrate by weight) from the selected plots. This inoculation method is a common procedure to investigate plant-soil interactions and has the advantage that only low amounts of living soil are needed and that potential abiotic feedbacks are eliminated (Pernilla Brinkman et al. 2010). To produce sterile background substrate, we collected 1.6 m^3 soil substrate from the Jena Experiment in May 2017. This soil substrate was a mix of excavated soil material from different experimental plots, which was stored for several years at the experimental area. The soil substrate was sieved to 10 mm, homogenized, and mixed with 0.4 m^3 quartz sand (WF 33, Quarzwerke GmbH, Walbeck, Germany). Afterwards, the soil-sand mix was steam-sterilized twice for 150 minutes at ~80°C. More information about the steam-sterilization method and changes of abiotic and biotic soil properties can be found in Dietrich et al. (2020).

For the preparation of study plants, QuickPot^{TM} trays of 20 cm^3 volume (Hermann Meyer KG, Rellingen, Germany) were sterilized with a potassium hypochlorite solution (Eau de Javel: 2.6 g KClO to 100 ml water; 1:1) and filled with an autoclaved mixture of sand and soil from the Jena Experiment (1:1; sterilized twice for 40 min at 121°C) in June 2017. Each species and origin (i.e. plot) was sown with two or three seeds per pot plate cell. QuickPot^{TM} trays were placed in an open greenhouse (Research Station Bad Lauchstädt, UFZ) to promote germination by natural daily temperature fluctuations. Trays were regularly watered (with demineralized water). On 29 June 2017, *A. pratensis* seeds were reseeded because of low germination rate. For the other three species, one seedling per pot plate cell was removed if more than two seeds were germinated.

Common garden experiment

In July 2017, 12 soil cores (5 cm diameter, 10 cm depth) were taken in a grid of 20 x 20 cm in each Dominance Experiment plot selected for the study and stored in a cooling chamber (4°C). Soil cores were pooled per plot and sieved through a sieve with 5 mm mesh size to remove stones and coarse roots. Then, 2800 cm^3 steam-sterilized background substrate was thoroughly mixed with 150 cm^3 fresh-sieved living soil and filled in a heat-cleaned pot (3 L, diameter 14.9 cm, height 18 cm) with 12 replicates per plot. Seedlings per pot plate cell were separated, and two seedlings per species with same plot origin were transplanted into one pot (Fig. 1). In four pots per plot, we transplanted plants, which had the same plot origin as the inoculated soil (home soil treatment); in the other eight pots, plant and soil origin were different (away soil treatment). In four of these away pots, species richness of plant and soil origin was the same, but plant species composition was different (away-same soil treatment), and in the other four away pots, species richness of plant and soil origin was different (away-different soil treatment; Fig. 1). Seedlings of *D. glomerata* were transplanted on 18 July 2017, followed by *A. elatius* (20 July 2017), *P. trivialis* (20 and 24 July 2017), and *A. pratensis* (26 – 28 July 2017). Seedlings were immediately watered with 200 ml demineralized water after transplantation, and the initial number of shoots was counted. In total, the experiment consisted of 576 pots, each with two plants. The pots were placed in an open greenhouse with a roof, which automatically closes at rain, and ambient temperatures (Research Station Bad Lauchstädt, UFZ). Pots were distributed in six blocks placing the 12 pots filled with soil from one plot in one block, i.e. in each block there were 12 pots with soil of one two-species and one six-species plot per species. The position of the pots within the blocks was randomly chosen and changed once a month to avoid potential side effects by neighboring pots and edge effects of the tables.

During the first week after planting, plants were watered every day with 200 ml demineralized water. From week two to four, all pots were watered every other day with 380 ml demineralized water without further treatments to allow the establishment of plants and soil biota in the pots (380 ml were used to achieve a water saturation of the soil of 60%; calculation can be found in Appendix S1). On 23 August 2017, treatments with the global change drivers were started. For every treatment (control, drought, nitrogen input, combination of drought and nitrogen input), we used three of the 12 pots per plot (one home, one away-same, and one away-different pot, respectively; Fig. 1).

(I) For control, pots were watered as before (380 ml; every other day) and were not fertilized.

(II) Drought was simulated by reduced water saturation (= 30% water saturation = 225 ml; calculation can be found in Appendix S1). Pots were still watered every other day but with 225 ml instead of 380 ml demineralized water.

(III) Nitrogen input was applied once a week with 95 mg NH_3NO_4 (33.125 mg nitrogen) resulting in a total nitrogen amount of 265 mg after eight fertilization events, which is equivalent to a nitrogen input of 150 kg ha^{-1} $year^{-1}$ nitrogen (medium value for managed grasslands in Germany; Häußermann et al 2019). Fertilized plants were watered as before (380 ml; every other day).

(IV) For the combination of drought and nitrogen input, pots were watered with a reduced amount (225 ml) and were fertilized once a week (in the same way as for the nitrogen input treatment alone).

Once a month, all pots were weighted before watering. The measured weight per pot was subtracted from dry soil weight plus the assigned amount of water (380 or 225 ml). The difference revealed the amount of water which was then used to water the pot to keep the anticipated levels of water saturation for the drought and control treatment.

Data collection

After 11 weeks of growth with global change driver treatments, plants were harvested block-wise (between 16 October and 8 November 2018). Before harvest, aboveground traits and leaf fungal pathogen infestation were measured (Table 1). For growth height (in cm), we measured the stretched shoot length of the longest vegetative shoot per plant. Only 15% of the plants had flowered, which was neglected due to the small case number. For leaf greenness (unitless estimate of foliar chlorophyll content), three fully expanded leaves from vegetative shoots of each plant were measured with a SPAD 502 Plus Chlorophyll Meter (Spectrum Technologies, Inc.) and values were averaged per plant. Stomatal conductance (g_s; mmol m^{-2} s^{-1}) was measured at one fully expanded leaf per plant (i.e. two leaves per pot) with a SC-1 Leaf Porometer (Decagon Devices Inc.). This was done block-wise and always one day after watering, between 10 a.m. and 3 p.m. Shortly before harvest, the percentage of total leaf area, which was infested by fungal pathogens was estimated for each plant. A subsample of leaves per species was taken to identify pathogens morphologically at the species level under a light microscope. Moreover, three fully expanded leaves per individual were cut, packed in wet paper towels to achieve water saturation, and stored overnight in a cooling chamber at 4°C. On the next day, leaves were weighed as bulk sample per pot (i.e. six leaves) after removing water droplets with tissue paper. Afterwards, total leaf area was measured with a leaf area meter (LI-3000C Area Meter equipped with LI3050C transparent conveyer belt accessory, LICOR, USA). LDMC was calculated as the ratio of dry weight to fresh weight (mg_{leaf} g_{leaf}^{-1}) and SLA as the ratio of leaf area to dry weight (mm_{leaf}^{2} mg_{leaf}^{-1}).

For biomass harvest, plants were cut at ground level, and roots were cleaned by rinsing off all soil over a 0.5 mm sieve. The fresh root biomass was weighed and a subsample of around 1-2 g fresh weight was stored at –20°C. At a later point, roots were thawed and scanned on a flatbed scanner at 800 dpi (Epson Expression 10000 XL scanner, Regent Instruments, Quebec, Canada), and root diameter and root length of the subsample were measured with an image analysis software (WinRHIZO; Regent Instruments, Quebec City, Canada). Specific root length

(SRL) was calculated as the ratio of root length to root dry biomass (of the subsample; m_{root} g_{root}^{-1}) and root length density (RLD) as the ratio of root length to soil volume in the pot (root length was extrapolated from the ratio of dry root biomass of the measured subsample to total dry root mass per pot; cm_{root} cm_{soil}^{-3}).

All biomass and leaf samples were dried at 70°C for 48 h and then weighed. To calculate total shoot biomass per pot (each with two individuals), dry shoot biomass and dry leaf mass of the sample used for leaf area measurements were added. To calculate total root biomass, dry biomass of the scanned subsample was extrapolated from the ratio of fresh root biomass to dry root biomass per pot and added to the weighed dry root biomass per pot.

For chemical analysis, shoot biomass of each pot was chopped, and a subsample was ground with a ball mill. Then, 10 mg milled material was used to determine shoot nitrogen concentration with near-infrared spectroscopy (MPA Multi Purpose FT-NIR Analyzer, Bruker GmbH, Ettlingen, Germany). The calibration models used to predict shoot nitrogen concentrations were derived from laboratory data generated from previous samples of grass species. The accuracy of the predictions was verified by a repeated nitrogen concentration analysis of 45 randomly selected samples with an elemental analyzer (Vario EL Element Analyzer, Elementar, Hanau, Germany). Significant positive correlation ($p < 0.001$, $r = 0.97$, $N = 45$) between concentrations resulted from near-infrared spectroscopy and analysis with the elemental analyzer demonstrate high accuracy of our predictions.

Data analysis

To test whether the plants performed differently depending on legacy treatments (plant history, soil history, soil treatment [home/away]), or type of global change treatment, linear mixed-effects models were fitted for all measured response variables per pot as summarized in Table 1. Furthermore, some variables were transformed to meet the assumptions of normality and variance homogeneity: if necessary, root biomass and RLD were square root-transformed and root-shoot ratio, SLA, stomatal conductance, SRL, and pathogen infestation were log-transformed. Furthermore, outlier values of LDMC of three *P. trivialis* pots (extremely low values), and LDMC and SLA of one *A. elatius* pot (extremely low LDMC, high SLA), were excluded from the analysis.

For mixed-effect model analysis, we started with a null model with the random effects only. We used seed plot identity (plot, where the seeds had been collected) and soil plot identity (plot, from which the inoculation soil had been taken) as random effects. Then, we successively added the fixed effects with species identity first, followed by the legacy treatments: plant history (species richness of the plant community, where the seeds had been collected: two or six), soil history (species richness of the plant community, where the soil for inoculation had been taken: two or six), and soil treatment (home, away-same, away-different), followed by the global change driver treatments: drought (control or drought) and nitrogen input (control or nitrogen), and finally all interactions between species identity and the other fixed effects to check whether species differ in their responses. For analysis of stomatal conductance, we used daytime and air temperature as covariates, which were entered before adding the experimental factors to account for possible effects of the measurement time.

Because of multiple significant interactions between species identity and other fixed effects (Table 2), we further analyzed the response variables separately per species. Therefore, we used the same fixed effect structure as explained above, but without species identity and additionally with the interactions between legacy treatments and global change driver treatments (which was not done in the first model, because otherwise, it would have become too complex). For pathogen infestation, we only analyzed data of *D. glomerata* and *P. trivialis*, because of very low infestation rates of *A. elatius* and *A. pratensis* plants. To test whether initial size influenced the performance of the phytometers later in the experiment, we added initial shoot number as a fixed effect before the other fixed effects in separate models for analysis of shoot and root biomass production.

Because of multiple significant interactions between legacy treatments and global change driver treatments (Appendix S2: Table S1-S10), we further analyzed the data for each global change driver treatment separately. We used plant history, soil history, and soil treatment as fixed effects for species-specific analysis, and for analyses across all four species, we extended the models by fitting species identity first and all possible interactions between species identity and legacy treatments in the end.

All models were fitted with maximum likelihood (ML), and likelihood ratio tests were used to decide on the significance of the fixed effects. Tukey's HSD test was used to test differences among soil treatment groups. All calculations and statistical analyses were done in R (version 3.6.1, R Development Core Team, http://www.R-project.org) including the package *lme4* (glmer and lmer) (Bates et al. 2015) and *multcomp* (Tukey HSD) (Hothorn et al. 2016) for mixed-effects model analysis.

Acknowledgements

We thank the technicians of the experimental research station Bad Lauchstädt, who helped with the establishment, maintenance and harvest of the experiment. Furthermore, we are grateful to Laura Bergmann for help during the experiment, and Peter Otto for identifying the fungal pathogens. The Jena Experiment is funded by the German Research Foundation (FOR 1451), supported by the University of Jena, the Max Planck Institute for Biogeochemistry and the German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, funded by the German Research Foundation (FZT 118). Further support was provided by the Heinrich Böll Foundation (PhD scholarship to PD).

Data availability

The data that support the findings of this study are openly available in BExIS at https://jexis.idiv.de/ddm/data/Showdata/238

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Appendix S1

Journal: eLife

Article: Diversity-induced plant history and soil history effects modulate plant responses to global change

Authors: Peter Dietrich, Jens Schumacher, Nico Eisenhauer, Christiane Roscher

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Calculation of irrigation water quantity per pot

1) After one week of growing, pots were watered until 100% saturation and then weighted (= Weight $_{\text{wet soil}}$).

2) To determine the amount of water, which is needed to get 60% water saturation (control value), we used the following equations:

$$\text{(I)}\quad \frac{22\%\ (\text{water holding capacity}) \times 60\%\ \text{saturation}}{100\%\ \text{saturation}} = 13.2\%$$

$$\text{(II)}\quad \text{Weight}_{\text{wet soil}} - \frac{\text{Weight}_{\text{wet soil}} \times 100\%\ \text{saturation}}{13.2\% + 100} = \text{Weight}_{\text{water control}}$$

First, we multiplied the water holding capacity of the Jena Experiment soil-sand mix (22%) times 60% saturation and then divided the result by 100% saturation. Second, Weight $_{\text{wet soil}}$ was multiplied with 100 and then divided by 113.2. Third, the calculated weight for a 60% saturation was subtracted from Weight $_{\text{wet soil}}$ per pot and averaged over all pots, which resulted in 380 ml water.

3) Drought was simulated by 50% lower water saturation (30% saturation), while the amount of water was calculated as followed:

$$\text{(I)}\quad \frac{22\%\ (\text{water holding capacity}) \times 30\%\ \text{saturation}}{100\%\ \text{saturation}} = 6.6\%$$

$$\textbf{(II)}\, \text{Weight}_{\text{wet soil}} - \frac{\text{Weight}_{\text{wet soil}} \times 100\%\ \text{saturation}}{6.6\% + 100} = \text{Weight}_{\text{water drought}}$$

Appendix S2

Journal: eLife

Article: Diversity-induced plant history and soil history effects modulate plant responses to global change

Authors: Peter Dietrich, Jens Schumacher, Nico Eisenhauer, Christiane Roscher

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Hypothesis 2: global change drivers have a strong impact on biomass production and trait expression.

Plant traits (separately for each species)

The grass *P. trivialis* was the only species which growth height decreased with drought, all other species showed no significant change under drought. Under nitrogen input, the species *P. trivialis, A. pratensis*, and *D. glomerata* (marginally significant) increased in growth height, while under the combined impact of both global change drivers, no species significantly changed in growth height (*D. glomerata* marginally significantly increased in height; Fig. S1). The species *A.elatius, D. glomerata,* and *A. pratensis* increased in shoot nitrogen concentration and leaf greenness under the impact of drought and/or nitrogen input (similar to analysis across all species; Fig. S1). In *P. trivialis*, drought did not affect shoot nitrogen concentration or leaf greenness, and there was no additive impact of both global change drivers on leaf greenness (leaf greenness was as high as in fertilized plants; Fig. S1).

Global change drivers had no significant influence on LDMC or SLA of *A. elatius* and *A. pratensis* except for LDMC decrease and SLA increase of *A. elatius* plants when treated with both global change drivers (Fig. S2). Plants of *D. glomerata* decreased in LDMC and increased in SLA when treated with single global change drivers, while nitrogen input had a stronger impact than drought (Fig. S2). When treated with both global change drivers, *D. glomerata* plants had still a significantly lower LDMC and higher SLA compared to control plants. In *P. trivialis*, drought had no significant influence on LDMC and SLA, while nitrogen input decreased LDMC and increased SLA (Fig. S2). When treated with both global change drivers, LDMC and SLA were as high as in fertilized plants.

In *D. glomerata*, stomatal conductance was increased, when plants were treated with drought, and in *A. pratensis* decreased, when treated with both global change drivers (Fig. S2). Stomatal conductance in *A. elatius* and *P. trivialis* did not change with global change treatments (Fig. S2).

In *A. elatius*, SRL decreased when fertilized, irrespective of drought, while other root traits did not change significantly (Fig. S3). In *A. pratensis*, drought, nitrogen input, and both global change drivers together had similar negative impacts on SRL and RLD (except for RLD under nitrogen input, which did not change; Fig. S3). Root diameter of *A. pratensis* plants increased under single global change drivers with additive effects under the combined application (Fig. S3). In *D. glomerata*, RLD increased and in *P. trivialis* RLD decreased and root diameter increased, when treated with both global change drivers (Fig. S3).

Figures

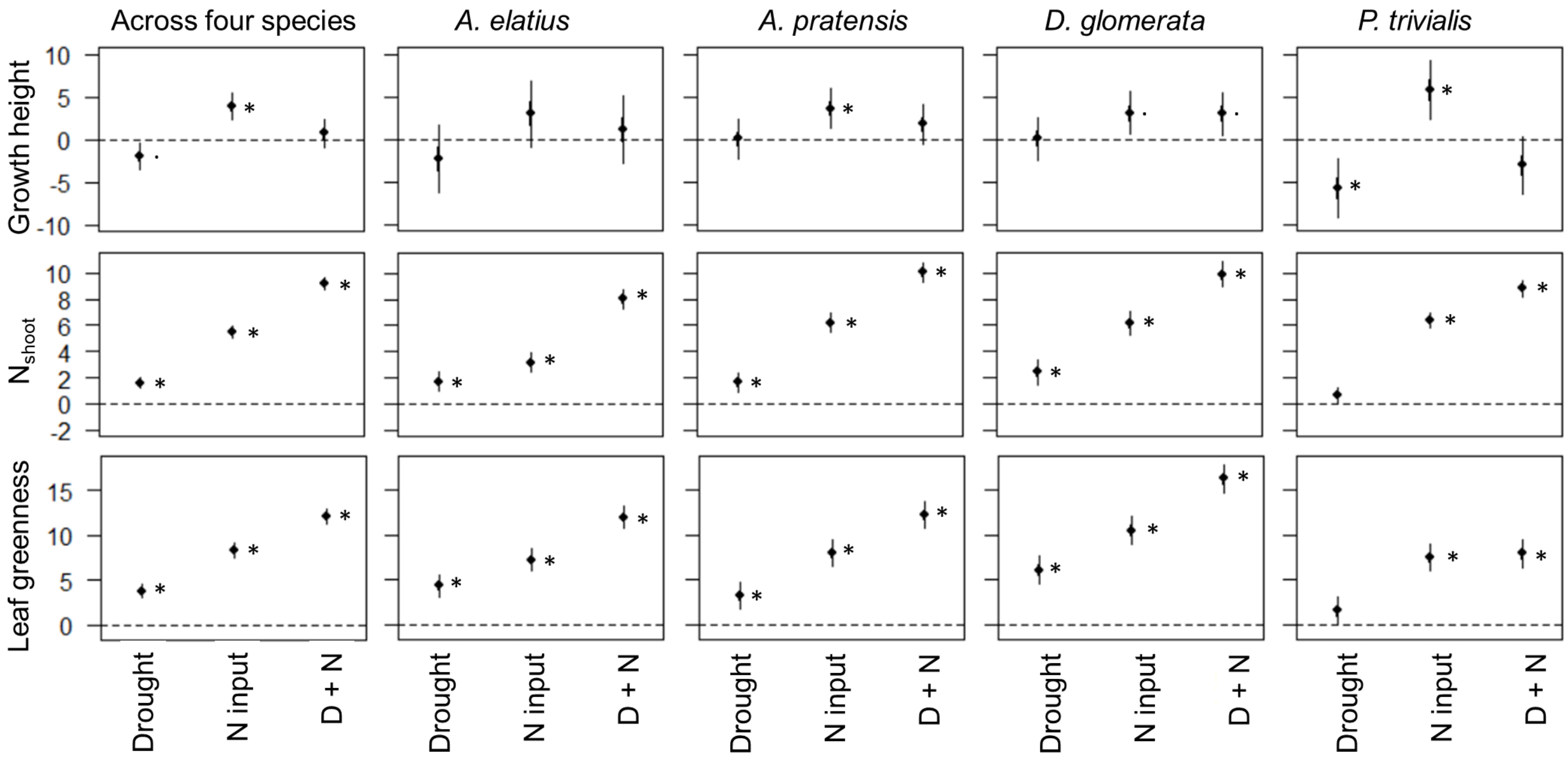

Figure S1 Response of plants treated with drought, nitrogen input or a combination of both (D+N) relative to non-treated plants (control) for growth height, shoot nitrogen concentrations and leaf greenness across all four study species and separately for each species. Points are means and error bars are standard deviation. Stars indicate significant differences ($P < 0.05$) between plants treated with GC driver and control plants.

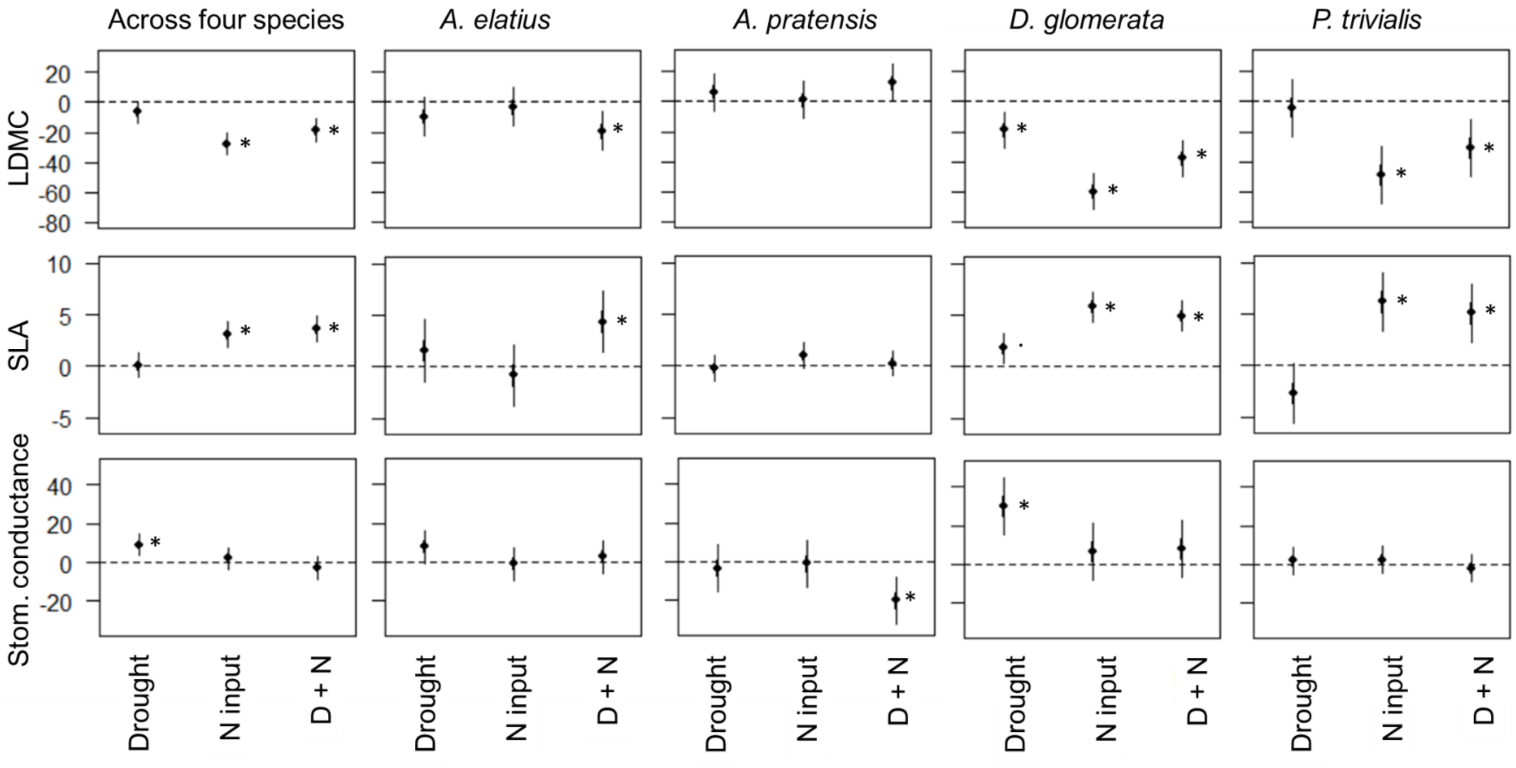

Figure S2 Response of plants treated with drought, nitrogen input or a combination of both (D+N) relative to non-treated plants (control) for LDMC, SLA and stomatal conductance across all four study species and separately for each species. Points are means and error bars are standard deviation. Stars indicate significant differences (P < 0.05) between plants treated with GC driver and control plants.

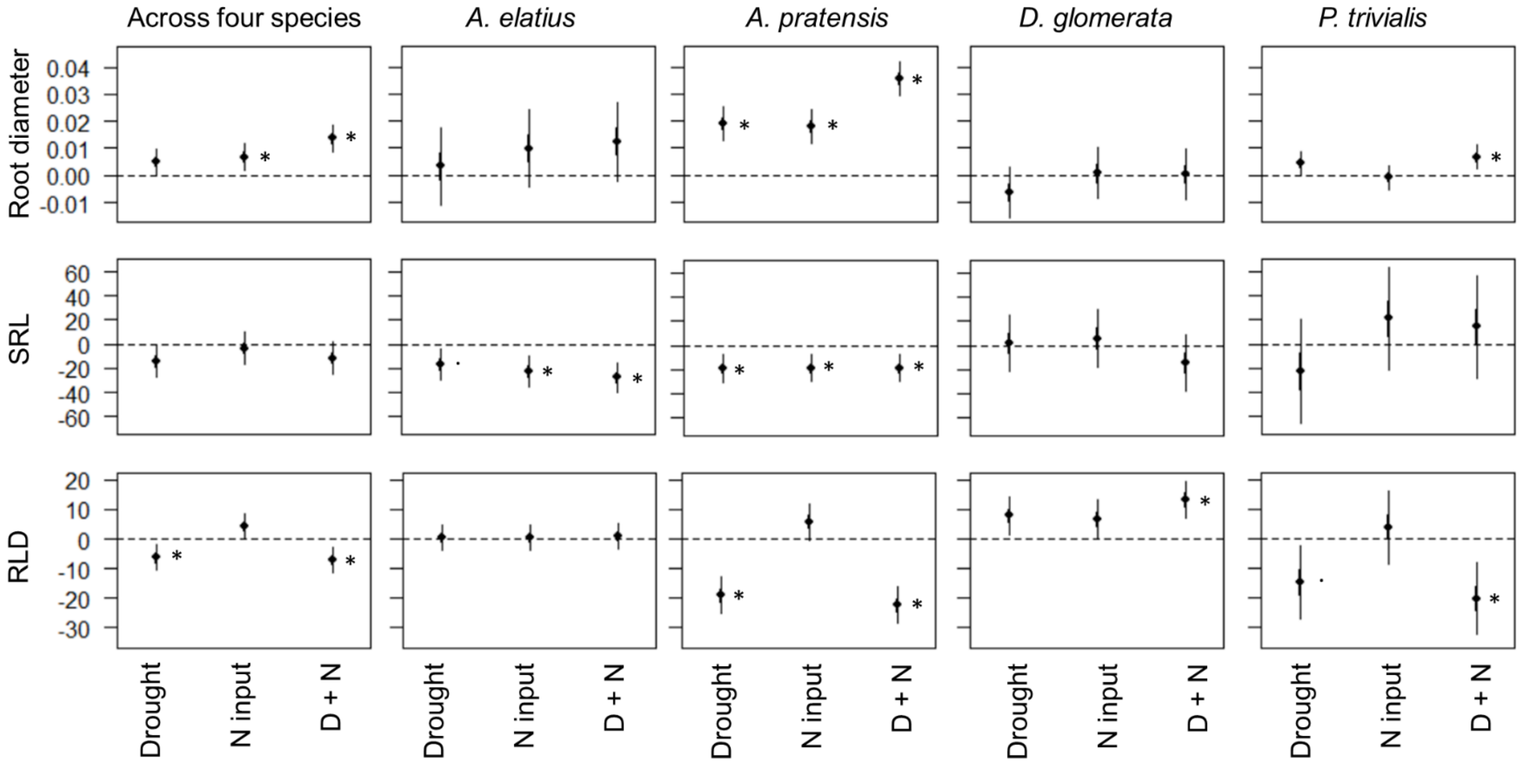

Figure S3 Response of plants treated with drought, nitrogen input or a combination of both (D+N) relative to non-treated plants (control) for root diameter, SRL and RLD across all four study species and separately for each species. Points are means and error bars are standard deviation. Stars indicate significant differences ($P < 0.05$) between plants treated with GC driver and control plants.

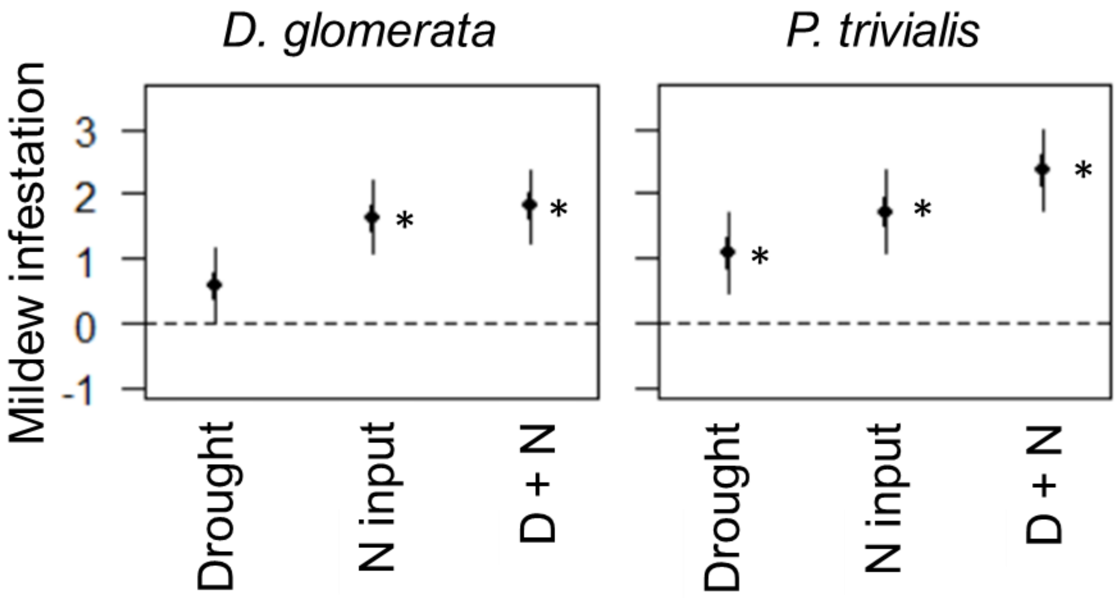

Figure S4 Response of plants treated with drought, nitrogen input or a combination of both (D+N) relative to non-treated plants (control) for mildew infestation for *D. glomerata* and *P. trivialis*. Stars indicate significant differences ($P < 0.05$) between plants treated with GC driver and control plants.

Tables

Table S1 Summary of mixed-effect model analyses testing the effects of species identity (N = 4), legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on root-shoot ratio. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

	Root-shoot ratio		
	Df	Chi^2	P
Species identity (ID)	3	133.41	**<0.001**
Plant history	1	1.11	0.292
Soil history	1	1.08	0.300
Soil treatment	2	1.81	0.404
Drought (D)	1	60.01	**<0.001**
Nitrogen input (N)	1	89.83	**<0.001**
Species ID x Plant history	3	0.87	0.832
Species ID x Soil history	3	4.07	0.254
Species ID x Soil treatment	6	2.79	0.835
Species ID x D	3	95.53	**<0.001**
Species ID x N	3	9.31	**0.025**
D x N	1	2.19	0.139
Species ID x Plant history x D	4	2.02	0.733
Species ID x Soil history x D	4	1.58	0.812
Species ID x Soil treatment x D	8	4.97	0.760
Species ID x Plant history x N	4	2.91	0.573
Species ID x Soil history x N	4	3.18	0.528
Species ID x Soil treatment x N	8	18.18	**0.020**
Species ID x Plant history x D x N	4	10.42	**0.034**
Species ID x Soil history x D x N	4	11.14	**0.025**
Species ID x Soil treatment x D x N	8	5.20	0.736

Table S2 Summary of mixed-effect model analyses testing the effects of species identity (N = 4), legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

	Total biomass			Shoot biomass			Root biomass			Root-shoot ratio		
	Df	Chi	P	Df	Chi	P	Df	Chi	P	Df	Chi	P
Species ID	3	73.25	**<0.001**	3	80.17	**<0.001**	3	121.30	**<0.001**	3	133.41	**<0.001**
Plant history	1	3.48	*0.062*	1	1.36	0.244	1	3.40	*0.065*	1	1.11	0.292
Soil history	1	0.01	0.915	1	0.04	0.851	1	0.49	0.484	1	1.08	0.300
Soil treatment	2	2.17	0.338	2	1.20	0.548	2	3.66	0.161	2	1.81	0.404
Drought (D)	1	83.05	**<0.001**	1	110.26	**<0.001**	1	2.81	*0.094*	1	60.01	**<0.001**
Nitrogen input (N)	1	257.26	**<0.001**	1	425.93	**<0.001**	1	15.89	**<0.001**	1	89.83	**<0.001**
D x N	1	29.23	**<0.001**	1	23.02	**<0.001**	1	8.50	**0.004**	1	1.75	0.185
Plant history x D	1	0.22	0.639	1	0.21	0.643	1	0.01	0.916	1	<0.01	0.977
Soil history x D	1	<0.01	0.944	1	0.07	0.786	1	0.10	0.746	1	0.23	0.635
Soil treatment x D	2	1.79	0.409	2	0.77	0.681	2	1.37	0.503	2	1.29	0.526
Plant history x N	1	1.48	0.224	1	1.59	0.207	1	0.60	0.437	1	0.35	0.553
Soil history x N	1	3.44	*0.064*	1	1.33	0.249	1	2.46	0.116	1	0.83	0.363
Soil treatment x N	2	1.43	0.489	2	1.40	0.496	2	0.43	0.806	2	0.49	0.782
Plant history x D x N	1	2.12	0.146	1	0.84	0.358	1	1.78	0.183	1	1.27	0.260
Soil history x D x N	1	0.95	0.330	1	2.78	*0.095*	1	0.08	0.780	1	0.03	0.864
Soil treatment x D x N	2	1.37	0.504	2	1.93	0.381	2	0.91	0.635	2	0.73	0.693

Table S3 Summary of mixed-effect model analyses testing the effects of species identity (N = 4), legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant trait expression. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

	Growth height			Shoot nitrogen conc.			Leaf greenness		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	71.45	**<0.001**	3	57.20	**<0.001**	3	79.55	**<0.001**
Plant history	1	0.15	0.694	1	<0.01	0.960	1	0.05	0.830
Soil history	1	1.60	0.207	1	0.64	0.425	1	0.17	0.683
Soil treatment	2	3.98	0.137	2	2.27	0.321	2	0.60	0.742
Drought (D)	1	18.71	**<0.001**	1	65.46	**<0.001**	1	66.15	**<0.001**
Nitrogen input (N)	1	32.93	**<0.001**	1	772.20	**<0.001**	1	523.86	**<0.001**
D x N	1	1.10	0.294	1	48.85	**<0.001**	1	<0.01	0.997
Plant history x D	1	2.99	*0.084*	1	0.06	0.806	1	<0.01	0.950
Soil history x D	1	0.51	0.477	1	0.11	0.735	1	1.57	0.210
Soil treatment x D	2	3.54	0.171	2	0.02	0.990	2	0.69	0.707
Plant history x N	1	0.50	0.478	1	1.34	0.246	1	0.91	0.341
Soil history x N	1	1.41	0.235	1	0.19	0.666	1	1.54	0.215
Soil treatment x N	2	1.87	0.392	2	3.30	0.192	2	2.42	0.299
Plant history x D x N	1	0.83	0.364	1	0.21	0.645	1	0.79	0.373
Soil history x D x N	1	0.69	0.407	1	3.06	*0.080*	1	<0.01	0.977
Soil treatment x D x N	2	4.94	*0.085*	2	1.56	0.458	2	0.04	0.983
	LDMC			SLA			Stomatal conductance		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Air temperature	-	-	-	-	-	-	1	5.34	**0.021**
Daytime	-	-	-	-	-	-	1	38.25	**<0.001**
Species ID	3	80.52	**<0.001**	3	124.00	**<0.001**	3	47.15	**<0.001**
Plant history	1	0.80	0.373	1	0.06	0.805	1	1.25	0.264
Soil history	1	0.10	0.750	1	1.22	0.270	1	0.37	0.543
Soil treatment	2	1.13	0.570	2	1.64	0.441	2	3.38	0.185
Drought (D)	1	0.94	0.333	1	0.11	0.743	1	0.90	0.343
Nitrogen input (N)	1	62.84	**<0.001**	1	61.63	**<0.001**	1	8.16	**0.004**
D x N	1	6.69	**0.010**	1	0.01	0.904	1	9.33	**0.002**
Plant history x D	1	0.04	0.841	1	0.34	0.559	1	0.06	0.806
Soil history x D	1	0.49	0.484	1	0.02	0.883	1	0.65	0.420
Soil treatment x D	2	0.24	0.887	2	0.23	0.889	2	0.18	0.914
Plant history x N	1	0.65	0.421	1	0.16	0.688	1	0.69	0.406
Soil history x N	1	0.12	0.734	1	1.07	0.300	1	0.63	0.428
Soil treatment x N	2	0.66	0.719	2	2.92	0.232	2	0.08	0.960
Plant history x D x N	1	0.16	0.687	1	1.77	0.183	1	0.87	0.351
Soil history x D x N	1	<0.01	0.962	1	0.95	0.331	1	0.02	0.887
Soil treatment x D x N	2	2.27	0.322	2	1.33	0.514	2	3.73	0.155
	Root diameter			SRL			RLD		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	165.58	**<0.001**	3	174.84	**<0.001**	3	125.84	**<0.001**
Plant history	1	0.03	0.872	1	0.32	0.569	1	1.14	0.286
Soil history	1	0.37	0.544	1	0.36	0.546	1	0.25	0.617
Soil treatment	2	1.50	0.473	2	2.80	0.246	2	4.97	*0.083*
Drought (D)	1	11.19	**0.001**	1	7.67	**0.006**	1	16.09	**<0.001**
Nitrogen input (N)	1	19.83	**<0.001**	1	6.68	**0.010**	1	1.29	0.257
D x N	1	0.25	0.619	1	1.27	0.261	1	2.14	0.144
Plant history x D	1	0.37	0.544	1	0.34	0.559	1	0.67	0.414
Soil history x D	1	0.12	0.725	1	0.48	0.491	1	0.07	0.798
Soil treatment x D	2	1.67	0.434	2	0.65	0.723	2	0.44	0.802
Plant history x N	1	0.40	0.528	1	1.91	0.167	1	<0.01	0.944
Soil history x N	1	0.42	0.515	1	0.15	0.703	1	0.86	0.353
Soil treatment x N	2	0.27	0.872	2	1.69	0.430	2	0.08	0.959
Plant history x D x N	1	0.20	0.652	1	1.22	0.270	1	0.12	0.734
Soil history x D x N	1	1.48	0.224	1	3.47	*0.063*	1	3.94	**0.047**
Soil treatment x D x N	2	0.75	0.686	2	0.84	0.659	2	1.02	0.600

Table S4 Summary of mixed-effect model analyses testing the effects legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio) of *A. elatius* and *A. pratensis*. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

	A. elatius											
	Total biomass			Shoot biomass			Root biomass			Root-shoot ratio		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.26	0.609	1	0.05	0.827	1	0.10	0.747	1	0.11	0.738
Soil history	1	0.39	0.533	1	0.03	0.865	1	1.02	0.312	1	1.28	0.258
Soil treatment	2	2.06	0.357	2	1.59	0.452	2	1.31	0.520	2	0.30	0.861
Drought (D)	1	21.54	**<0.001**	1	50.79	**<0.001**	1	6.13	**0.013**	1	67.84	**<0.001**
Nitrogen input (N)	1	125.48	**<0.001**	1	128.72	**<0.001**	1	31.68	**<0.001**	1	13.70	**<0.001**
D x N	1	36.23	**<0.001**	1	45.06	**<0.001**	1	1.86	0.173	1	0.13	0.715
Plant history x D	1	1.01	0.315	1	2.37	0.123	1	0.05	0.823	1	1.28	0.258
Soil history x D	1	0.27	0.606	1	2.01	0.156	1	0.71	0.399	1	2.11	0.146
Soil treatment x D	2	1.21	0.545	2	3.22	0.200	2	0.13	0.939	2	1.21	0.545
Plant history x N	1	0.92	0.337	1	2.00	0.157	1	0.02	0.879	1	0.46	0.497
Soil history x N	1	0.87	0.352	1	0.05	0.832	1	1.37	0.242	1	2.29	0.130
Soil treatment x N	2	3.07	0.215	2	0.80	0.669	2	6.25	**0.044**	2	5.64	*0.060*
Plant history x D x N	1	0.07	0.792	1	<0.01	0.980	1	0.15	0.696	1	0.02	0.884
Soil history x D x N	1	0.61	0.434	1	0.05	0.822	1	0.89	0.344	1	1.17	0.279
Soil treatment x D x N	2	3.61	0.165	2	2.25	0.326	2	1.33	0.515	2	0.56	0.757

	A. pratensis											
	Total biomass			Shoot biomass			Root biomass			Root-shoot ratio		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.57	0.452	1	0.42	0.518	1	0.43	0.512	1	<0.01	0.985
Soil history	1	0.68	0.408	1	<0.01	0.945	1	1.47	0.225	1	0.80	0.371
Soil treatment	2	0.34	0.845	2	0.29	0.865	2	0.23	0.892	2	0.07	0.967
Drought (D)	1	71.43	**<0.001**	1	38.06	**<0.001**	1	60.92	**<0.001**	1	0.15	0.696
Nitrogen input (N)	1	74.74	**<0.001**	1	162.92	**<0.001**	1	9.71	**0.002**	1	55.50	**<0.001**
D x N	1	26.47	**<0.001**	1	3.98	**0.046**	1	24.94	**<0.001**	1	16.49	**<0.001**
Plant history x D	1	0.08	0.772	1	0.51	0.477	1	0.48	0.488	1	1.07	0.301
Soil history x D	1	0.43	0.512	1	0.37	0.546	1	0.20	0.653	1	0.01	0.912
Soil treatment x D	2	1.17	0.557	2	0.19	0.911	2	2.12	0.346	2	3.60	0.165
Plant history x N	1	0.40	0.529	1	1.26	0.261	1	0.02	0.875	1	0.14	0.709
Soil history x N	1	5.45	**0.020**	1	1.19	0.275	1	4.53	**0.033**	1	1.24	0.265
Soil treatment x N	2	2.78	0.249	2	2.50	0.287	2	1.21	0.547	2	0.13	0.938
Plant history x D x N	1	0.55	0.458	1	0.02	0.881	1	0.59	0.442	1	0.08	0.771
Soil history x D x N	1	0.28	0.595	1	0.30	0.585	1	0.78	0.376	1	1.44	0.230
Soil treatment x D x N	2	0.91	0.634	2	0.05	0.975	2	1.45	0.485	2	2.41	0.300

Table S5 Summary of mixed-effect model analyses testing the effects legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio) of *D. glomerata* and *P. trivialis*. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

	D. glomerata											
	Total biomass			Shoot biomass			Root biomass			Root-shoot ratio		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.51	0.219	1	1.32	0.251	1	1.12	0.289	1	0.19	0.662
Soil history	1	0.00	0.957	1	0.01	0.912	1	0.07	0.787	1	0.05	0.829
Soil treatment	2	0.79	0.673	2	0.11	0.948	2	2.65	0.266	2	2.94	0.230
Drought (D)	1	0.98	0.323	1	12.71	**<0.001**	1	20.48	**<0.001**	1	58.54	**<0.001**
Nitrogen input (N)	1	82.06	**<0.001**	1	124.42	**<0.001**	1	8.87	**0.003**	1	16.79	**<0.001**
D x N	1	0.07	0.790	1	0.04	0.843	1	0.61	0.434	1	0.53	0.467
Plant history x D	1	0.05	0.821	1	0.55	0.458	1	0.24	0.623	1	1.40	0.236
Soil history x D	1	0.56	0.453	1	2.20	0.138	1	0.14	0.706	1	0.27	0.601
Soil treatment x D	2	0.09	0.955	2	0.55	0.758	2	1.09	0.579	2	3.01	0.222
Plant history x N	1	1.55	0.213	1	1.85	0.174	1	0.62	0.432	1	0.29	0.592
Soil history x N	1	1.42	0.234	1	2.24	0.135	1	0.26	0.612	1	0.25	0.618
Soil treatment x N	2	0.05	0.976	2	0.72	0.699	2	1.94	0.378	2	3.83	0.147
Plant history x D x N	1	4.64	**0.031**	1	3.35	*0.067*	1	4.09	**0.043**	1	3.81	*0.051*
Soil history x D x N	1	4.21	**0.040**	1	3.68	*0.055*	1	2.87	*0.090*	1	1.64	0.200
Soil treatment x D x N	2	1.70	0.428	2	3.03	0.220	2	0.66	0.718	2	0.32	0.853

	P. trivialis											
	Total biomass			Shoot biomass			Root biomass			Root-shoot ratio		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.91	0.340	1	0.03	0.870	1	1.49	0.222	1	1.36	0.244
Soil history	1	0.26	0.611	1	0.08	0.781	1	2.43	0.119	1	4.29	**0.038**
Soil treatment	2	1.23	0.540	2	1.18	0.556	2	0.62	0.732	2	0.09	0.956
Drought (D)	1	23.05	**<0.001**	1	22.42	**<0.001**	1	8.93	**0.003**	1	0.00	0.988
Nitrogen input (N)	1	27.28	**<0.001**	1	87.31	**<0.001**	1	1.12	0.290	1	45.86	**<0.001**
D x N	1	3.81	*0.051*	1	2.16	0.141	1	2.81	*0.094*	1	2.10	0.147
Plant history x D	1	0.08	0.775	1	1.03	0.311	1	0.03	0.874	1	0.20	0.656
Soil history x D	1	<0.01	0.969	1	0.21	0.649	1	0.15	0.696	1	0.21	0.646
Soil treatment x D	2	0.80	0.670	2	0.69	0.708	2	0.38	0.828	2	1.04	0.594
Plant history x N	1	<0.01	0.972	1	0.87	0.350	1	0.32	0.569	1	0.73	0.391
Soil history x N	1	<0.01	0.984	1	0.01	0.936	1	0.01	0.920	1	0.03	0.857
Soil treatment x N	2	4.20	0.123	2	1.87	0.392	2	6.33	**0.042**	2	7.28	**0.026**
Plant history x D x N	1	0.25	0.614	1	<0.01	0.978	1	0.17	0.680	1	0.00	0.972
Soil history x D x N	1	0.02	0.890	1	1.11	0.292	1	1.09	0.296	1	2.88	*0.089*
Soil treatment x D x N	2	0.35	0.838	2	0.49	0.782	2	1.16	0.559	2	1.97	0.373

Table S6 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant trait expressions of *A. elatius*. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

A. elatius	Growth height			Shoot nitrogen conc.			Leaf greenness		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.24	0.625	1	0.12	0.725	1	0.07	0.795
Soil history	1	0.61	0.436	1	0.36	0.547	1	0.67	0.413
Soil treatment	2	2.01	0.365	2	0.80	0.670	2	0.19	0.907
Drought (D)	1	2.11	0.146	1	36.64	**<0.001**	1	30.19	**<0.001**
Nitrogen input (N)	1	5.35	**0.021**	1	142.97	**<0.001**	1	153.54	**<0.001**
D x N	1	0.02	0.881	1	32.71	**<0.001**	1	0.27	0.604
Plant history x D	1	4.68	**0.030**	1	1.41	0.236	1	0.48	0.487
Soil history x D	1	0.01	0.904	1	0.26	0.612	1	0.06	0.813
Soil treatment x D	2	3.10	0.212	2	0.38	0.827	2	1.58	0.453
Plant history x N	1	1.15	0.284	1	1.08	0.300	1	3.76	*0.053*
Soil history x N	1	0.61	0.434	1	0.20	0.656	1	1.09	0.295
Soil treatment x N	2	3.03	0.220	2	0.27	0.874	2	2.37	0.305
Plant history x D x N	1	0.59	0.443	1	1.85	0.174	1	0.37	0.545
Soil history x D x N	1	0.93	0.334	1	0.03	0.854	1	0.06	0.813
Soil treatment x D x N	2	7.64	**0.022**	2	0.26	0.877	2	1.95	0.377
	LDMC			SLA			Stomatal conductance		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Air temperature	-	-	-	-	-	-	1	<0.01	0.948
Daytime	-	-	-	-	-	-	1	8.05	**0.005**
Plant history	1	0.46	0.500	5	1.69	0.194	1	0.49	0.486
Soil history	1	0.19	0.666	6	1.83	0.176	1	0.05	0.823
Soil treatment	2	1.37	0.504	8	1.14	0.565	2	3.38	0.184
Drought (D)	1	7.57	**0.006**	9	12.37	**<0.001**	1	4.58	**0.032**
Nitrogen input (N)	1	1.05	0.307	10	0.05	0.832	1	2.00	0.158
D x N	1	0.02	0.889	11	1.87	0.171	1	0.17	0.681
Plant history x D	1	1.48	0.224	12	1.94	0.164	1	1.08	0.298
Soil history x D	1	0.36	0.549	13	0.79	0.373	1	0.05	0.830
Soil treatment x D	2	<0.01	0.998	15	1.73	0.420	2	0.73	0.693
Plant history x N	1	0.01	0.904	16	0.08	0.782	1	0.04	0.836
Soil history x N	1	0.01	0.936	17	1.69	0.193	1	0.36	0.549
Soil treatment x N	2	2.16	0.339	19	2.01	0.367	2	0.24	0.886
Plant history x D x N	1	<0.01	0.999	20	1.96	0.162	1	0.42	0.518
Soil history x D x N	1	0.10	0.752	21	0.15	0.696	1	1.48	0.224
Soil treatment x D x N	2	0.35	0.840	23	0.50	0.781	2	1.99	0.369
	Root diameter			SRL			RLD		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.08	0.783	1	0.31	0.576	1	0.09	0.767
Soil history	1	0.23	0.629	1	0.22	0.639	1	0.82	0.364
Soil treatment	2	2.89	0.236	2	5.30	*0.071*	2	3.35	0.187
Drought (D)	1	0.32	0.572	1	5.25	**0.022**	1	0.04	0.851
Nitrogen input (N)	1	3.46	*0.063*	1	13.72	**<0.001**	1	0.13	0.723
D x N	1	0.01	0.932	1	1.62	0.204	1	<0.01	0.989
Plant history x D	1	0.39	0.531	1	0.11	0.740	1	0.77	0.380
Soil history x D	1	0.01	0.938	1	0.95	0.329	1	0.29	0.590
Soil treatment x D	2	2.11	0.349	2	0.51	0.775	2	0.45	0.797
Plant history x N	1	0.09	0.764	1	1.41	0.235	1	1.29	0.256
Soil history x N	1	1.35	0.246	1	0.32	0.573	1	3.53	*0.060*
Soil treatment x N	2	0.68	0.711	2	1.06	0.590	2	1.76	0.416
Plant history x D x N	1	1.68	0.194	1	2.73	*0.099*	1	3.70	*0.054*
Soil history x D x N	1	4.45	**0.035**	1	0.52	0.469	1	1.46	0.227
Soil treatment x D x N	2	2.00	0.369	2	2.75	0.253	2	2.26	0.324

Table S7 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant trait expressions of *A. pratensis*. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

A. pratensis	Growth height			Shoot nitrogen conc.			Leaf greenness		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.35	0.246	1	0.16	0.687	1	0.49	0.485
Soil history	1	0.71	0.400	1	<0.01	0.967	1	0.11	0.745
Soil treatment	2	8.50	**0.014**	2	1.38	0.501	2	0.20	0.903
Drought (D)	1	1.07	0.300	1	15.42	**<0.001**	1	16.09	**<0.001**
Nitrogen input (N)	1	10.63	**0.001**	1	246.65	**<0.001**	1	143.35	**<0.001**
D x N	1	1.40	0.236	1	17.58	**<0.001**	1	0.86	0.353
Plant history x D	1	0.16	0.692	1	<0.01	0.979	1	0.58	0.446
Soil history x D	1	0.31	0.577	1	0.52	0.471	1	3.04	*0.081*
Soil treatment x D	2	1.11	0.575	2	0.50	0.778	2	3.39	0.183
Plant history x N	1	0.28	0.597	1	0.17	0.681	1	<0.01	0.994
Soil history x N	1	0.01	0.919	1	0.10	0.747	1	1.10	0.293
Soil treatment x N	2	2.42	0.299	2	6.58	**0.037**	2	0.19	0.911
Plant history x D x N	1	0.18	0.672	1	0.87	0.352	1	1.06	0.304
Soil history x D x N	1	0.45	0.501	1	0.49	0.485	1	0.03	0.863
Soil treatment x D x N	2	0.85	0.654	2	2.08	0.353	2	0.32	0.854
	LDMC			SLA			Stomatal conductance		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Air temperature	-	-	-	-	-	-	1	0.16	0.685
Daytime	-	-	-	-	-	-	1	1.78	0.182
Plant history	1	2.82	*0.093*	1	0.19	0.665	1	0.43	0.513
Soil history	1	1.80	0.180	1	0.94	0.332	1	0.41	0.520
Soil treatment	2	3.57	0.168	2	5.69	*0.058*	2	3.67	0.159
Drought (D)	1	4.02	**0.045**	1	1.29	0.255	1	6.17	**0.013**
Nitrogen input (N)	1	0.75	0.388	1	2.93	*0.087*	1	3.64	*0.056*
D x N	1	0.33	0.566	1	0.41	0.524	1	3.45	*0.063*
Plant history x D	1	0.13	0.715	1	0.27	0.604	1	0.03	0.862
Soil history x D	1	0.16	0.685	1	<0.01	0.980	1	0.64	0.423
Soil treatment x D	2	1.40	0.497	2	1.39	0.499	2	0.01	0.993
Plant history x N	1	1.03	0.311	1	1.02	0.313	1	0.58	0.447
Soil history x N	1	<0.01	0.950	1	0.78	0.377	1	0.18	0.669
Soil treatment x N	2	0.64	0.726	2	2.56	0.278	2	0.27	0.874
Plant history x D x N	1	0.80	0.372	1	1.67	0.197	1	2.57	0.109
Soil history x D x N	1	4.17	**0.041**	1	1.01	0.315	1	0.23	0.634
Soil treatment x D x N	2	0.18	0.912	2	1.09	0.581	2	15.71	**<0.001**
	Root diameter			SRL			RLD		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.01	0.935	1	0.28	0.597	1	0.06	0.809
Soil history	1	0.18	0.676	1	0.01	0.934	1	0.92	0.337
Soil treatment	2	0.54	0.763	2	0.97	0.615	2	0.12	0.940
Drought (D)	1	39.31	**<0.001**	1	5.25	**0.022**	1	82.01	**<0.001**
Nitrogen input (N)	1	51.80	**<0.001**	1	5.33	**0.021**	1	0.34	0.560
D x N	1	0.09	0.767	1	5.57	**0.018**	1	4.32	**0.038**
Plant history x D	1	0.01	0.906	1	0.30	0.587	1	0.26	0.611
Soil history x D	1	0.09	0.769	1	0.01	0.910	1	0.02	0.877
Soil treatment x D	2	2.58	0.276	2	4.88	0.087	2	0.11	0.948
Plant history x N	1	0.03	0.869	1	0.19	0.660	1	0.17	0.682
Soil history x N	1	6.39	**0.011**	1	8.14	**0.004**	1	0.63	0.426
Soil treatment x N	2	1.82	0.402	2	3.27	0.195	2	1.24	0.539
Plant history x D x N	1	0.54	0.461	1	0.15	0.700	1	0.28	0.594
Soil history x D x N	1	1.82	0.178	1	1.87	0.172	1	0.27	0.605
Soil treatment x D x N	2	3.23	0.199	2	1.63	0.443	2	0.70	0.703

Table S8 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant trait expressions of *D. glomerata*. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

D. glomerata	Growth height			Shoot nitrogen conc.			Leaf greenness		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.05	0.831	1	0.58	0.444	1	0.22	0.640
Soil history	1	1.56	0.212	1	1.35	0.245	1	0.27	0.606
Soil treatment	2	5.25	*0.073*	2	0.75	0.687	2	0.55	0.760
Drought (D)	1	<0.01	0.976	1	19.10	**<0.001**	1	29.41	**<0.001**
Nitrogen input (N)	1	11.51	**0.001**	1	183.85	**<0.001**	1	172.91	**<0.001**
D x N	1	<0.01	0.949	1	3.72	0.054	1	0.08	0.781
Plant history x D	1	0.01	0.920	1	0.05	0.828	1	2.75	*0.097*
Soil history x D	1	0.82	0.366	1	0.08	0.774	1	0.22	0.639
Soil treatment x D	2	0.48	0.785	2	0.25	0.880	2	0.21	0.899
Plant history x N	1	0.91	0.341	1	2.96	*0.086*	1	0.61	0.437
Soil history x N	1	0.23	0.633	1	0.32	0.571	1	1.75	0.186
Soil treatment x N	2	0.35	0.840	2	0.29	0.866	2	4.92	*0.085*
Plant history x D x N	1	0.12	0.733	1	1.62	0.204	1	0.54	0.462
Soil history x D x N	1	0.71	0.400	1	5.07	**0.024**	1	<0.01	0.998
Soil treatment x D x N	2	0.06	0.969	2	2.15	0.341	2	0.33	0.846
	LDMC			SLA			Stomatal conductance		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Air temperature	-	-	-	-	-	-	1	0.39	0.531
Daytime	-	-	-	-	-	-	1	20.31	**<0.001**
Plant history	1	0.12	0.727	1	0.80	0.371	1	5.08	**0.024**
Soil history	1	0.58	0.445	1	0.32	0.573	1	<0.01	0.944
Soil treatment	2	0.58	0.749	2	1.20	0.548	2	0.54	0.765
Drought (D)	1	0.07	0.798	1	0.54	0.461	1	9.01	**0.003**
Nitrogen input (N)	1	55.57	**<0.001**	1	57.43	**<0.001**	1	2.72	*0.099*
D x N	1	20.69	**<0.001**	1	6.61	**0.010**	1	6.34	**0.012**
Plant history x D	1	0.04	0.842	1	0.46	0.498	1	0.07	0.793
Soil history x D	1	0.01	0.926	1	0.09	0.762	1	<0.01	0.991
Soil treatment x D	2	1.43	0.490	2	0.09	0.958	2	0.19	0.907
Plant history x N	1	0.99	0.320	1	0.02	0.893	1	0.32	0.571
Soil history x N	1	2.48	0.115	1	2.19	0.139	1	0.69	0.406
Soil treatment x N	2	0.13	0.938	2	1.56	0.459	2	0.09	0.958
Plant history x D x N	1	2.00	0.157	1	0.09	0.768	1	0.33	0.566
Soil history x D x N	1	1.30	0.254	1	4.99	**0.026**	1	5.98	**0.014**
Soil treatment x D x N	2	3.56	0.169	2	1.09	0.579	2	1.57	0.456
	Root diameter			SRL			RLD		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.60	0.438	1	0.96	0.326	1	2.61	0.107
Soil history	1	0.06	0.805	1	0.07	0.791	1	0.01	0.933
Soil treatment	2	0.07	0.967	2	0.58	0.749	2	2.44	0.296
Drought (D)	1	0.93	0.335	1	1.16	0.281	1	9.45	**0.002**
Nitrogen input (N)	1	1.22	0.270	1	0.37	0.545	1	7.05	**0.008**
D x N	1	0.80	0.370	1	1.73	0.189	1	0.08	0.773
Plant history x D	1	3.60	*0.058*	1	0.64	0.425	1	0.25	0.614
Soil history x D	1	1.41	0.235	1	0.62	0.430	1	0.23	0.632
Soil treatment x D	2	0.65	0.721	2	1.95	0.377	2	2.43	0.297
Plant history x N	1	0.19	0.667	1	2.05	0.152	1	0.03	0.854
Soil history x N	1	0.60	0.437	1	<0.01	0.994	1	0.21	0.646
Soil treatment x N	2	0.85	0.653	2	0.97	0.616	2	1.76	0.414
Plant history x D x N	1	1.49	0.222	1	0.14	0.712	1	3.11	*0.078*
Soil history x D x N	1	0.49	0.483	1	3.54	*0.060*	1	1.07	0.301
Soil treatment x D x N	2	1.65	0.438	2	1.16	0.559	2	0.20	0.907

Table S9 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on plant trait expressions of *P. trivialis*. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

P. trivialis	Growth height			Shoot nitrogen conc.			Leaf greenness		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.06	0.800	1	0.00	0.997	1	0.93	0.334
Soil history	1	2.29	0.131	1	0.05	0.824	1	1.10	0.294
Soil treatment	2	1.66	0.435	2	0.51	0.776	2	1.15	0.563
Drought (D)	1	30.17	**<0.001**	1	5.46	**0.019**	1	1.42	0.233
Nitrogen input (N)	1	12.16	**<0.001**	1	297.03	**<0.001**	1	108.82	**<0.001**
D x N	1	1.72	0.190	1	17.06	**<0.001**	1	1.09	0.296
Plant history x D	1	0.22	0.637	1	0.11	0.736	1	3.08	*0.079*
Soil history x D	1	2.28	0.131	1	0.53	0.469	1	0.06	0.806
Soil treatment x D	2	3.11	0.211	2	1.03	0.598	2	0.18	0.916
Plant history x N	1	5.16	**0.023**	1	0.05	0.821	1	0.13	0.719
Soil history x N	1	3.49	**0.062**	1	0.04	0.842	1	0.36	0.549
Soil treatment x N	2	2.08	0.354	2	1.04	0.594	2	1.98	0.371
Plant history x D x N	1	0.92	0.336	1	0.03	0.865	1	0.11	0.738
Soil history x D x N	1	0.13	0.718	1	0.18	0.669	1	0.00	0.967
Soil treatment x D x N	2	2.11	0.348	2	5.57	*0.062*	2	1.74	0.418
	LDMC			SLA			Stomatal conductance		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Air temperature	-	-	-	-	-	-	1	38.70	**<0.001**
Daytime	-	-	-	-	-	-	1	18.64	**<0.001**
Plant history	1	<0.01	0.965	1	0.62	0.431	1	0.18	0.675
Soil history	1	0.08	0.777	1	0.49	0.485	1	0.71	0.399
Soil treatment	2	1.64	0.441	2	2.12	0.346	2	3.25	0.197
Drought (D)	1	2.85	*0.091*	1	2.75	*0.097*	1	0.22	0.636
Nitrogen input (N)	1	57.72	**<0.001**	1	41.44	**<0.001**	1	0.06	0.800
D x N	1	0.39	0.534	1	0.62	0.431	1	2.87	*0.090*
Plant history x D	1	1.09	0.296	1	0.38	0.540	1	2.86	*0.091*
Soil history x D	1	2.26	0.133	1	0.45	0.502	1	0.01	0.908
Soil treatment x D	2	0.19	0.908	2	1.33	0.515	2	0.40	0.819
Plant history x N	1	3.37	*0.066*	1	1.56	0.212	1	0.35	0.554
Soil history x N	1	0.54	0.461	1	0.21	0.645	1	2.45	0.118
Soil treatment x N	2	1.89	0.388	2	3.10	0.213	2	1.36	0.508
Plant history x D x N	1	0.13	0.720	1	0.58	0.446	1	0.14	0.704
Soil history x D x N	1	1.15	0.283	1	1.01	0.315	1	7.44	**0.006**
Soil treatment x D x N	2	3.30	0.192	2	0.99	0.610	2	2.20	0.333
	Root diameter			SRL			RLD		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	2.10	0.147	1	2.38	0.123	1	0.04	0.840
Soil history	1	0.08	0.781	1	0.30	0.581	1	1.31	0.253
Soil treatment	2	0.13	0.938	2	0.31	0.856	2	1.13	0.568
Drought (D)	1	14.18	**<0.001**	1	0.89	0.347	1	18.25	**<0.001**
Nitrogen input (N)	1	0.17	0.677	1	3.49	*0.062*	1	0.03	0.872
D x N	1	0.88	0.349	1	0.25	0.618	1	1.16	0.282
Plant history x D	1	0.40	0.525	1	0.27	0.602	1	0.16	0.692
Soil history x D	1	0.48	0.487	1	0.20	0.655	1	1.36	0.244
Soil treatment x D	2	5.85	*0.054*	2	0.50	0.777	2	0.43	0.808
Plant history x N	1	1.28	0.258	1	0.07	0.795	1	0.28	0.594
Soil history x N	1	1.21	0.271	1	0.36	0.549	1	0.65	0.418
Soil treatment x N	2	2.99	0.225	2	9.11	**0.011**	2	0.33	0.846
Plant history x D x N	1	0.33	0.566	1	0.05	0.821	1	0.02	0.878
Soil history x D x N	1	4.11	**0.043**	1	9.74	**0.002**	1	2.06	0.151
Soil treatment x D x N	2	0.52	0.772	2	1.40	0.495	2	1.43	0.488

Table S10 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment), global change treatments (drought, nitrogen input) and their interactions on mildew infestation of *D. glomerata* and *P. trivialis*. Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

Mildew infestation	*D. glomerata*			*P. trivialis*		
	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.29	0.588	1	0.01	0.939
Soil history	1	0.24	0.622	1	4.16	**0.041**
Soil treatment	2	0.22	0.896	2	3.36	0.187
Drought (D)	1	2.44	0.119	1	10.69	**0.001**
Nitrogen input (N)	1	42.75	**<0.001**	1	38.76	**<0.001**
D x N	1	1.05	0.305	1	0.98	0.321
Plant history x D	1	0.03	0.855	1	0.02	0.889
Soil history x D	1	2.25	0.134	1	0.07	0.788
Soil treatment x D	2	5.79	*0.055*	2	0.25	0.884
Plant history x N	1	<0.01	0.953	1	0.25	0.614
Soil history x N	1	0.21	0.643	1	0.50	0.477
Soil treatment x N	2	0.32	0.854	2	1.22	0.544
Plant history x D x N	1	3.00	*0.083*	1	0.09	0.770
Soil history x D x N	1	1.69	0.193	1	0.93	0.335
Soil treatment x D x N	2	7.15	**0.028**	2	0.62	0.734

Appendix S3

Journal: eLife

Article: Diversity-induced plant history and soil history effects modulate plant responses to global change

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Hypothesis 3: offspring of plants selected at different diversity and grown in different soil (high vs. low diversity, home vs. away) respond differently to global change drivers

Plant traits and pathogen infestation (across species and for each species)

Growth height did not differ depending on soil or plant history when plants were treated with global change drivers across all study species and for *D. glomerata* (Table S1, S4). Plants of *A. elatius* in home soil were smaller than plants in away-same soil (Table S2). Nitrogen input had no influence, while plants were tallest in home soil and smallest in away-different soil when treated with both global change drivers (Table S2). Plants of *A. pratensis* exposed to drought were taller when grown in home than in away-different soil; however, this positive home effect was also only found in control plants (marginal significant; Table S3). When fertilized, the positive home effect on growth height disappeared (Table S3). Plants of *P. trivialis* were taller in two- than in six-species community soil when treated with both global change drivers, but they were not different when treated separately with drought or nitrogen input (Table S5).

Leaf greenness and shoot nitrogen concentrations were not influenced by legacy treatments when exposed to drought. When fertilized, plants still did not differ in leaf greenness but had higher shoot nitrogen concentrations in six-species than in two-species soil, found across all study species and for *D. glomerata* (Table S1, S4). Moreover, fertilized plants had a lower shoot nitrogen concentration in home than in away-different soil, found across all species and for *A. pratensis* (Table S1, S3). When plants were treated with both global change drivers, the nitrogen input effect on soil history was cancelled out by drought (across all species and for *D. glomerata*), while the impact of soil treatment did not: plants in home soil still had lower shoot nitrogen concentration than plants in away soil (across all species and for *A. pratensis*).

Plants treated with global change drivers did not differ significantly in LDMC or SLA dependent on legacy treatments, across all study species and in *A. elatius* (Table S1, S2). Drought resulted in higher LDMC of *A. pratensis* plants grown in six-species soil, and the combined application of drought and nitrogen input resulted in lower SLA in home than in away soil (Table S3). Fertilized *D. glomerata* plants had higher SLA in six- than in two-species community soil (Table S4). Plants of *P. trivialis* treated with both global change drivers had lower LDMC in two- than in six-species community soil (Table S5).

Stomatal conductance (g_s) did not differ significantly depending on legacy treatments when plants were treated with global change drivers across all study species and for *A. elatius* and *P. trivialis* (Table S1, S2, S5). In *A. pratensis*, fertilized plants showed a lower g_s when grown in home than in away soil. This effect was cancelled out by drought, when treated with both global change drivers (Table S3). In *D. glomerata*, plants had higher g_s when originated from six-species communities and treated with both global change drivers; however, this was also found in control plants (Table S4).

Across all study species, root diameter, SRL and RLD were not influenced by legacy treatments when treated with global change drivers (Table S1). In *A. elatius*, root traits also did not differ, when treated with single global change drivers, but under the combined influence of both global change drivers, plants grown in away-different soil showed the highest SRL, and plants in away-same soil had the lowest SRL (Table S2). In *A. pratensis*, plants exposed to drought had higher SRL and RLD in two- than in six-species soil. When fertilized, we did not find an effect of legacy treatment, but the combination of both global change drivers led to higher SRL and lower root diameter when plants were grown in away-same than in away-different or home soil (Table S3). In *D. glomerata*, RLD of plants exposed to drought was higher when originated from six-species than from two-species communities. This positive diversity impact disappeared when fertilized (Table S4). In *P. trivialis*, SRL were lower in plants grown in six-species community soil, when exposed to drought. When fertilized, this difference disappeared (Table S5).

Mildew infestation of *D. glomerata* plants exposed to drought was higher in home than in away soil, while this drought effect was cancelled out by nitrogen input (Table S6). Mildew infestation of *P. trivialis* plants was not significantly influenced by plant or soil history, neither with nor without global change drivers (Table S6).

Figures

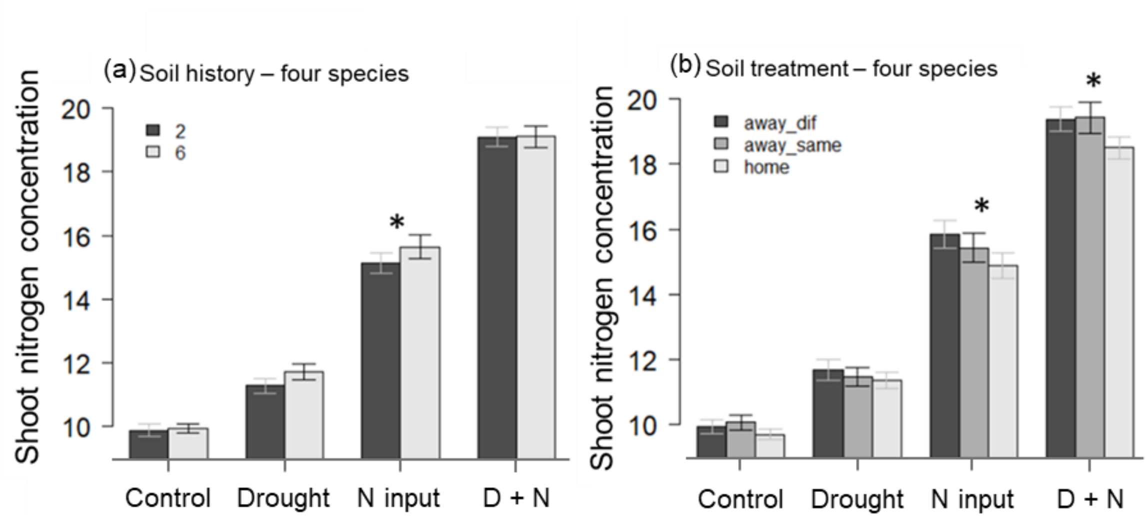


Figure S1 Shoot nitrogen concentrations (mg N g_{shoot}^{-1}) across all four species (a) grown in soil from two- or six-species communities and (b) grown in away-different (away_dif), away-same or home soil, and either non-treated (“Control”), treated with drought (“Drought”), with nitrogen (“N input”) or a combination of drought and nirogen input (“D + N”). Bars show mean values (± 1 SE); stars above bars indicate significant differences ($P < 0.05$).

Tables

Table S1 Summary of mixed-effect model analyses testing the effects of species identity, legacy treatments (plant history, soil history, soil treatment) and their interactions on plant trait expressions, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

	Growth height											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	36.51	**<0.001**	3	46.47	**<0.001**	3	26.45	**<0.001**	3	53.85	**<0.001**
Plant history (PH)	1	1.76	0.185	1	1.08	0.299	1	0.06	0.812	1	0.75	0.387
Soil history (SH)	1	0.48	0.488	1	0.86	0.354	1	1.52	0.217	1	1.40	0.237
Soil treatment (ST)	2	3.99	0.136	2	5.49	*0.064*	2	2.68	0.262	2	4.37	0.113
Species ID x PH	3	4.12	0.249	3	4.53	0.210	3	2.62	0.455	3	0.17	0.982
Species ID x SH	3	3.65	0.301	3	1.16	0.762	3	1.14	0.766	3	6.66	*0.084*
Species ID x ST	6	8.19	0.224	6	13.52	**0.035**	6	6.01	0.423	6	7.18	0.305

	Shoot nitrogen concentration											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	49.63	**<0.001**	3	23.08	**<0.001**	3	73.52	**<0.001**	3	30.02	**<0.001**
Plant history (PH)	1	0.94	0.333	1	0.08	0.775	1	0.50	0.480	1	0.03	0.871
Soil history (SH)	1	<0.01	0.963	1	1.50	0.221	1	4.67	**0.031**	1	<0.01	0.953
Soil treatment (ST)	2	2.94	0.230	2	1.32	0.517	2	7.52	**0.023**	2	8.53	**0.014**
Species ID x PH	3	2.80	0.424	3	5.03	0.170	3	4.00	0.262	3	2.20	0.533
Species ID x SH	3	1.14	0.767	3	2.99	0.392	3	7.02	*0.071*	3	0.31	0.958
Species ID x ST	6	12.36	*0.054*	6	6.88	0.332	6	6.13	0.409	6	4.73	0.579

	Leaf greenness											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	45.88	**<0.001**	3	44.96	**<0.001**	3	54.85	**<0.001**	3	71.04	**<0.001**
Plant history (PH)	1	1.61	0.204	1	0.11	0.740	1	0.43	0.514	1	0.02	0.876
Soil history (SH)	1	0.18	0.675	1	1.84	0.175	1	1.04	0.308	1	0.11	0.738
Soil treatment (ST)	2	2.10	0.350	2	1.62	0.444	2	0.41	0.813	2	1.62	0.445
Species ID x PH	3	4.39	0.222	3	3.98	0.264	3	1.88	0.600	3	2.78	0.427
Species ID x SH	3	4.45	0.216	3	3.44	0.329	3	0.89	0.829	3	0.35	0.950
Species ID x ST	6	3.54	0.739	6	3.92	0.688	6	8.79	0.186	6	3.38	0.759

	LDMC											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	32.76	**<0.001**	3	22.47	**<0.001**	3	78.30	**<0.001**	3	43.04	**<0.001**
Plant history (PH)	1	0.33	0.565	1	2.01	0.156	1	0.03	0.861	1	0.03	0.870
Soil history (SH)	1	0.02	0.887	1	0.56	0.456	1	0.06	0.808	1	0.17	0.680
Soil treatment (ST)	2	2.83	0.243	2	1.27	0.529	2	1.34	0.511	2	0.80	0.670
Species ID x PH	3	1.71	0.635	3	0.26	0.967	3	1.00	0.802	3	4.79	0.188
Species ID x SH	3	1.69	0.638	3	4.04	0.257	3	5.48	0.140	3	2.91	0.405
Species ID x ST	6	3.52	0.742	6	1.10	0.981	6	5.73	0.454	6	11.22	*0.082*

	SLA											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	86.36	**<0.001**	3	57.20	**<0.001**	3	101.71	**<0.001**	3	73.53	**<0.001**
Plant history (PH)	1	0.19	0.661	1	0.39	0.530	1	1.55	0.214	1	0.33	0.567
Soil history (SH)	1	0.64	0.425	1	0.01	0.926	1	3.35	*0.067*	1	0.26	0.607
Soil treatment (ST)	2	4.38	0.112	2	1.43	0.488	2	2.32	0.313	2	1.50	0.472
Species ID x PH	3	1.58	0.663	3	1.26	0.738	3	0.96	0.810	3	4.38	0.223
Species ID x SH	3	2.26	0.521	3	1.47	0.690	3	3.69	0.297	3	1.90	0.592
Species ID x ST	6	2.38	0.882	6	2.88	0.824	6	4.08	0.666	6	14.22	**0.027**

Table S1 continued

	Stomatal conductance											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Temperature	1	0.75	0.388	1	1.40	0.237	1	3.18	*0.074*	1	0.18	0.670
Daytime	1	18.95	**<0.001**	1	13.20	**<0.001**	1	5.72	**<0.001**	1	16.06	**<0.001**
Species ID	3	45.36	**<0.001**	3	24.61	**<0.001**	3	42.88	**<0.001**	3	21.71	**<0.001**
Plant history (PH)	1	0.60	0.438	1	0.01	0.910	1	0.48	0.490	1	2.95	*0.086*
Soil history (SH)	1	0.10	0.757	1	0.05	0.818	1	1.15	0.283	1	0.07	0.797
Soil treatment (ST)	2	0.08	0.963	2	2.67	0.263	2	4.85	*0.088*	2	0.20	0.905
Species ID x PH	3	4.59	0.204	3	3.18	0.365	3	4.89	0.180	3	4.89	0.180
Species ID x SH	3	2.60	0.457	3	3.53	0.317	3	3.23	0.358	3	3.36	0.340
Species ID x ST	6	8.36	0.213	6	4.47	0.614	6	3.82	0.701	6	4.76	0.575
	Root diameter											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	97.02	**<0.001**	3	103.81	**<0.001**	3	93.37	**<0.001**	3	106.66	**<0.001**
Plant history (PH)	1	0.87	0.352	1	0.02	0.883	1	<0.01	0.951	1	0.08	0.775
Soil history (SH)	1	0.17	0.680	1	0.22	0.643	1	1.41	0.235	1	0.03	0.873
Soil treatment (ST)	2	2.42	0.298	2	0.93	0.629	2	1.28	0.528	2	0.46	0.793
Species ID x PH	3	0.79	0.852	3	0.19	0.979	3	4.53	0.291	3	3.28	0.350
Species ID x SH	3	6.10	0.107	3	3.40	0.334	3	5.40	0.145	3	0.31	0.959
Species ID x ST	6	9.36	0.155	6	2.06	0.914	6	1.41	0.965	6	13.49	**0.036**
	SRL											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	125.58	**<0.001**	3	123.96	**<0.001**	3	117.21	**<0.001**	3	144.90	**<0.001**
Plant history (PH)	1	0.31	0.579	1	0.04	0.833	1	2.81	*0.094*	1	0.05	0.830
Soil history (SH)	1	<0.01	0.986	1	1.17	0.279	1	1.37	0.242	1	1.48	0.224
Soil treatment (ST)	2	1.46	0.483	2	0.67	0.717	2	4.01	0.135	2	0.28	0.869
Species ID x PH	3	5.15	0.161	3	2.11	0.550	3	2.96	0.397	3	2.31	0.510
Species ID x SH	3	3.89	0.274	3	6.14	0.105	3	3.40	0.334	3	1.93	0.586
Species ID x ST	6	13.23	**0.040**	6	2.92	0.819	6	2.90	0.821	6	14.70	**0.023**
	RLD											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	99.14	**<0.001**	3	101.33	**<0.001**	3	91.27	**<0.001**	3	75.25	**<0.001**
Plant history (PH)	1	0.00	0.956	1	3.36	*0.067*	1	0.11	0.742	1	0.98	0.323
Soil history (SH)	1	2.93	*0.087*	1	0.14	0.710	1	0.67	0.413	1	0.55	0.460
Soil treatment (ST)	2	2.50	0.286	2	2.56	0.279	2	0.03	0.983	2	4.98	*0.083*
Species ID x PH	3	1.35	0.716	3	5.11	0.164	3	2.59	0.459	3	0.59	0.900
Species ID x SH	3	5.42	0.144	3	2.89	0.409	3	0.45	0.929	3	0.49	0.921
Species ID x ST	6	2.77	0.838	6	4.44	0.617	6	0.91	0.989	6	6.27	0.393

Table S2 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant trait expressions of *A. elatius*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

A. elatius	Growth height											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.32	0.569	1	2.94	*0.087*	1	1.01	0.314	1	0.13	0.719
Soil history	1	1.50	0.221	1	0.07	0.787	1	0.14	0.706	1	0.29	0.593
Soil treatment	2	2.67	0.263	2	10.64	**0.005**	2	1.55	0.461	2	7.58	**0.023**
	Shoot nitrogen concentration											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.52	0.472	1	3.46	*0.063*	1	<0.01	0.974	1	0.06	0.802
Soil history	1	0.89	0.347	1	0.04	0.843	1	1.64	0.200	1	0.06	0.803
Soil treatment	2	1.40	0.497	2	1.54	0.462	2	1.99	0.369	2	2.07	0.354
	Leaf greenness											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.19	0.275	1	0.60	0.438	1	1.13	0.288	1	0.22	0.636
Soil history	1	1.50	0.221	1	0.99	0.321	1	0.03	0.862	1	0.15	0.699
Soil treatment	2	5.20	*0.074*	2	0.44	0.801	2	3.64	0.162	2	0.84	0.656
	LDMC											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.01	0.942	1	1.15	0.284	1	<0.01	0.987	1	1.02	0.313
Soil history	1	0.07	0.798	1	0.13	0.718	1	0.04	0.837	1	0.31	0.580
Soil treatment	2	0.03	0.985	2	0.34	0.844	2	2.00	0.369	2	2.44	0.295
	SLA											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.44	0.507	1	0.61	0.435	1	0.48	0.488	1	1.63	0.202
Soil history	1	0.04	0.836	1	0.22	0.638	1	0.88	0.348	1	1.08	0.300
Soil treatment	2	0.59	0.744	2	0.13	0.936	2	2.74	0.254	2	3.10	0.212
	Stomatal conductance											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Temperature	1	0.05	0.827	1	0.53	0.465	1	0.91	0.340	1	0.09	0.763
Daytime	1	6.15	**0.013**	1	3.92	**0.048**	1	0.68	0.408	1	0.37	0.544
Plant history	1	0.49	0.484	1	0.05	0.824	1	1.23	0.267	1	0.18	0.670
Soil history	1	0.83	0.361	1	0.13	0.718	1	0.92	0.336	1	<0.01	0.998
Soil treatment	2	0.96	0.618	2	1.69	0.429	2	2.99	0.224	2	0.33	0.846
	Root diameter											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.24	0.627	1	<0.01	0.972	1	0.46	0.497	1	0.45	0.503
Soil history	1	1.37	0.242	1	0.53	0.467	1	2.59	0.108	1	0.10	0.754
Soil treatment	2	4.85	*0.089*	2	0.52	0.770	2	1.00	0.605	2	3.86	0.145
	SRL											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.80	0.371	1	0.16	0.686	1	2.32	0.128	1	0.54	0.462
Soil history	1	0.06	0.807	1	0.02	0.884	1	2.66	0.103	1	0.21	0.649
Soil treatment	2	2.94	0.230	2	1.81	0.404	2	4.63	*0.099*	2	9.49	**0.009**
	RLD											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.02	0.313	1	0.03	0.859	1	2.42	0.120	1	1.44	0.230
Soil history	1	2.51	0.113	1	1.14	0.286	1	1.03	0.310	1	0.46	0.500
Soil treatment	2	4.52	0.104	2	1.24	0.539	2	0.26	0.878	2	1.40	0.497

Table S3 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant trait expressions of *A. pratensis*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

A. pratensis	Growth height											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.50	0.221	1	0.56	0.454	1	0.03	0.868	1	0.94	0.332
Soil history	1	0.44	0.508	1	0.15	0.700	1	0.03	0.874	1	0.82	0.365
Soil treatment	2	5.77	*0.056*	2	6.56	**0.038**	2	3.00	0.223	2	0.26	0.879
	Shoot nitrogen concentration											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.75	0.186	1	0.17	0.680	1	0.10	0.755	1	0.84	0.358
Soil history	1	0.37	0.544	1	0.96	0.328	1	0.01	0.939	1	0.00	0.966
Soil treatment	2	4.61	*0.100*	2	1.74	0.419	2	9.05	**0.011**	2	6.83	**0.033**
	Leaf greenness											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.07	0.786	1	1.03	0.311	1	0.58	0.445	1	0.18	0.673
Soil history	1	0.03	0.869	1	1.85	0.174	1	0.90	0.343	1	0.19	0.661
Soil treatment	2	1.16	0.560	2	0.60	0.743	2	0.61	0.737	2	2.21	0.332
	LDMC											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.34	0.561	1	0.38	0.538	1	0.40	0.527	1	2.17	0.140
Soil history	1	0.11	0.736	1	3.62	*0.057*	1	2.32	0.128	1	0.05	0.821
Soil treatment	2	0.36	0.835	2	1.42	0.492	2	1.18	0.555	2	3.91	0.141
	SLA											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.07	0.786	1	0.32	0.572	1	0.00	0.984	1	1.28	0.259
Soil history	1	0.20	0.654	1	2.81	*0.094*	1	0.23	0.632	1	0.05	0.828
Soil treatment	2	2.21	0.331	2	0.70	0.704	2	1.18	0.555	2	8.59	**0.014**
	Stomatal conductance											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Temperature	1	1.17	0.279	1	0.22	0.642	1	0.44	0.507	1	0.17	0.678
Daytime	1	0.77	0.379	1	0.07	0.786	1	1.13	0.289	1	8.38	**0.004**
Plant history	1	0.05	0.824	1	0.16	0.690	1	0.66	0.415	1	0.61	0.436
Soil history	1	1.30	0.255	1	0.14	0.706	1	0.79	0.373	1	0.53	0.466
Soil treatment	2	2.35	0.308	2	4.41	0.110	2	2.55	**0.002**	2	1.59	0.452
	Root diameter											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.28	0.595	1	0.18	0.673	1	0.20	0.653	1	0.09	0.770
Soil history	1	5.61	**0.018**	1	0.95	0.331	1	1.34	0.246	1	0.01	0.942
Soil treatment	2	1.02	0.602	2	0.29	0.865	2	1.25	0.535	2	6.06	**0.048**
	SRL											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.42	0.515	1	0.24	0.623	1	0.61	0.435	1	0.01	0.916
Soil history	1	0.33	0.567	1	7.10	**0.008**	1	0.17	0.677	1	2.73	*0.098*
Soil treatment	2	5.24	*0.073*	2	0.88	0.644	2	0.11	0.945	2	6.03	**0.049**
	RLD											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.28	0.595	1	0.12	0.729	1	0.08	0.781	1	0.09	0.763
Soil history	1	0.75	0.387	1	4.79	**0.029**	1	0.13	0.716	1	0.03	0.861
Soil treatment	2	0.28	0.869	2	2.39	0.303	2	0.19	0.909	2	3.02	0.221

Table S4 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant trait expressions of *D. glomerata*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

D. glomerata	Growth height											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.73	0.394	1	0.11	0.741	1	0.06	0.802	1	0.01	0.912
Soil history	1	0.69	0.405	1	0.91	0.340	1	1.25	0.263	1	0.18	0.675
Soil treatment	2	1.66	0.436	2	1.06	0.589	2	2.37	0.306	2	1.09	0.581
	Shoot nitrogen concentration											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.13	0.289	1	0.56	0.455	1	2.38	0.123	1	0.56	0.453
Soil history	1	<0.01	0.952	1	2.18	0.140	1	8.44	**0.004**	1	0.05	0.818
Soil treatment	2	2.72	0.257	2	2.46	0.293	2	3.07	0.215	2	0.71	0.701
	Leaf greenness											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	4.93	**0.026**	1	0.02	0.886	1	0.17	0.680	1	0.13	0.723
Soil history	1	1.23	0.267	1	1.17	0.279	1	0.15	0.703	1	0.01	0.908
Soil treatment	2	2.33	0.313	2	3.58	0.167	2	1.16	0.560	2	0.68	0.713
	LDMC											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.86	0.353	1	1.18	0.278	1	0.37	0.540	1	0.64	0.423
Soil history	1	2.03	0.154	1	0.12	0.727	1	2.21	0.137	1	0.28	0.594
Soil treatment	2	2.36	0.307	2	0.20	0.905	2	1.74	0.418	2	3.05	0.218
	SLA											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.41	0.235	1	0.01	0.904	1	1.50	0.220	1	0.14	0.706
Soil history	1	2.29	0.130	1	0.28	0.595	1	3.86	**0.050**	1	0.02	0.888
Soil treatment	2	2.60	0.272	2	1.88	0.392	2	0.09	0.956	2	0.89	0.641
	Stomatal conductance											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Temperature	1	1.12	0.289	1	<0.01	0.951	1	0.04	0.843	1	0.08	0.782
Daytime	1	24.06	**<0.001**	1	12.16	**<0.001**	1	4.04	**0.044**	1	4.37	**0.037**
Plant history	1	3.77	*0.052*	1	1.05	0.304	1	1.79	0.181	1	4.89	**0.027**
Soil history	1	1.44	0.231	1	1.55	0.214	1	0.47	0.493	1	2.34	0.126
Soil treatment	2	0.43	0.805	2	1.62	0.445	2	0.27	0.872	2	1.04	0.595
	Root diameter											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.64	0.422	1	0.02	0.876	1	1.83	0.176	1	2.43	0.119
Soil history	1	0.33	0.567	1	2.50	0.114	1	0.34	0.559	1	0.16	0.691
Soil treatment	2	0.60	0.741	2	3.21	0.201	2	0.16	0.924	2	2.03	0.363
	SRL											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	2.55	0.111	1	0.54	0.462	1	0.08	0.777	1	0.36	0.548
Soil history	1	1.73	0.188	1	1.42	0.233	1	0.32	0.570	1	0.22	0.643
Soil treatment	2	2.23	0.329	2	0.24	0.888	2	2.28	0.320	2	2.38	0.304
	RLD											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.01	0.923	1	7.58	**0.006**	1	0.77	0.380	1	0.03	0.862
Soil history	1	0.27	0.602	1	0.02	0.901	1	0.54	0.464	1	0.18	0.673
Soil treatment	2	0.36	0.835	2	4.51	0.105	2	0.96	0.619	2	5.25	*0.073*

Table S5 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant trait expressions of *P. trivialis*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

P. trivialis	Growth height											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	2.81	*0.094*	1	0.32	0.571	1	0.98	0.323	1	0.16	0.688
Soil history	1	0.62	0.429	1	0.92	0.338	1	1.12	0.289	1	5.02	**0.025**
Soil treatment	2	4.77	*0.092*	2	1.59	0.452	2	2.99	0.224	2	1.14	0.566
	Shoot nitrogen concentration											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	<0.01	0.986	1	0.01	0.934	1	0.07	0.785	1	0.01	0.915
Soil history	1	0.15	0.695	1	0.57	0.452	1	0.06	0.802	1	0.45	0.503
Soil treatment	2	9.66	**0.008**	2	2.33	0.313	2	1.18	0.554	2	3.86	0.145
	Leaf greenness											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.14	0.708	1	2.41	0.120	1	0.04	0.845	1	2.35	0.126
Soil history	1	1.41	0.236	1	1.10	0.295	1	0.38	0.537	1	0.09	0.769
Soil treatment	2	0.13	0.936	2	0.37	0.833	2	5.22	*0.074*	2	0.97	0.616
	LDMC											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.81	0.369	1	0.24	0.627	1	0.05	0.826	1	1.34	0.247
Soil history	1	0.08	0.776	1	0.01	0.927	1	0.47	0.492	1	4.25	**0.039**
Soil treatment	2	3.34	0.188	2	0.72	0.696	2	3.01	0.222	2	2.64	0.268
	SLA											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.26	0.611	1	0.21	0.643	1	1.44	0.231	1	0.80	0.372
Soil history	1	0.41	0.522	1	0.40	0.528	1	1.47	0.226	1	0.33	0.565
Soil treatment	2	2.29	0.319	2	0.53	0.769	2	3.35	0.187	2	4.08	0.130
	Stomatal conductance											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Temperature	1	10.96	**0.001**	1	8.08	**0.004**	1	7.25	**0.007**	1	4.31	**0.038**
Daytime	1	3.93	**0.047**	1	1.12	0.289	1	1.22	0.270	1	6.35	**0.012**
Plant history	1	<0.01	0.949	1	0.60	0.439	1	2.96	*0.085*	1	0.29	0.589
Soil history	1	0.68	0.410	1	0.95	0.330	1	2.72	*0.099*	1	0.14	0.704
Soil treatment	2	2.46	0.293	2	0.54	0.763	2	0.95	0.622	2	1.49	0.474
	Root diameter											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.16	0.686	1	0.07	0.794	1	0.55	0.458	1	2.91	*0.088*
Soil history	1	3.06	*0.080*	1	0.31	0.579	1	0.95	0.329	1	0.06	0.800
Soil treatment	2	7.48	**0.024**	2	0.28	0.870	2	0.07	0.967	2	2.00	0.369
	SRL											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	2.10	0.147	1	0.94	0.332	1	1.82	0.178	1	1.04	0.308
Soil history	1	1.83	0.177	1	3.68	*0.055*	1	2.26	0.133	1	0.19	0.660
Soil treatment	2	5.73	*0.057*	2	0.56	0.755	2	1.97	0.374	2	1.83	0.401
	RLD											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.23	0.632	1	0.01	0.904	1	0.01	0.920	1	0.54	0.463
Soil history	1	3.38	*0.066*	1	0.07	0.792	1	0.01	0.926	1	0.16	0.685
Soil treatment	2	0.63	0.731	2	0.61	0.739	2	0.16	0.924	2	3.25	0.197

Table S6 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on mildew infestation of *D. glomerata* and *P. trivialis*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

Mildew infestation	*D. glomerata*											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.58	0.447	1	1.18	0.277	1	0.88	0.348	1	0.26	0.613
Soil history	1	0.41	0.522	1	2.63	0.105	1	<0.01	0.946	1	0.11	0.746
Soil treatment	2	6.01	**0.049**	2	7.65	**0.022**	2	0.93	0.628	2	0.09	0.958
	P. trivialis											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	<0.01	0.996	1	<0.01	0.973	1	0.03	0.860	1	0.21	0.647
Soil history	1	1.20	0.274	1	2.66	0.103	1	1.68	0.195	1	0.05	0.817
Soil treatment	2	3.94	0.139	2	1.78	0.412	2	0.16	0.921	2	2.10	0.350

Biomass production

Table S7 Summary of mixed-effect model analyses testing the effects of species identity (N = 4), legacy treatments (plant history, soil history, soil treatment) and their interactions on root-shoot ratio, when non-treated (control) or treated with global change drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

	Root-Shoot ratio											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Species ID	3	115.37	**<0.001**	3	116.36	**<0.001**	3	101.12	**<0.001**	3	108.37	**<0.001**
Plant history (PH)	1	0.02	0.880	1	1.48	0.225	1	1.64	0.200	1	0.46	0.496
Soil history (SH)	1	1.81	0.178	1	1.60	0.206	1	0.24	0.622	1	<0.01	0.992
Soil treatment (ST)	2	0.46	0.793	2	1.96	0.376	2	1.19	0.551	2	3.54	0.170
Species ID x PH	3	3.88	0.275	3	1.47	0.690	3	0.86	0.836	3	2.77	0.428
Species ID x SH	3	5.98	0.113	3	3.99	0.263	3	2.53	0.471	3	3.71	0.295
Species ID x ST	6	10.54	0.104	6	6.76	0.344	6	1.85	0.933	6	14.79	**0.022**

Table S8 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio) of *A. elatius*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

A. elatius	Total biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.35	0.557	1	0.82	0.364	1	0.71	0.401	1	0.26	0.613
Soil history	1	1.08	0.298	1	0.76	0.383	1	0.06	0.811	1	0.47	0.494
Soil treatment	2	0.10	0.949	2	2.91	0.233	2	6.44	**0.040**	2	0.99	0.610
	Shoot biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.12	0.726	1	3.36	*0.067*	1	1.27	0.260	1	0.01	0.904
Soil history	1	0.35	0.556	1	0.24	0.621	1	0.55	0.460	1	0.63	0.428
Soil treatment	2	2.08	0.354	2	2.89	0.236	2	5.24	*0.073*	2	0.98	0.613
	Root biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.03	0.860	1	0.15	0.701	1	0.01	0.916	1	0.36	0.551
Soil history	1	3.81	*0.051*	1	0.62	0.433	1	0.17	0.676	1	0.22	0.636
Soil treatment	2	2.05	0.359	2	2.38	0.304	2	2.25	0.325	2	1.68	0.432
	Root-shoot ratio											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.07	0.797	1	1.62	0.203	1	0.16	0.691	1	0.31	0.576
Soil history	1	4.86	**0.027**	1	0.24	0.626	1	0.50	0.479	1	0.07	0.787
Soil treatment	2	3.11	0.211	2	2.39	0.302	2	0.18	0.915	2	1.88	0.391

Table S9 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio) of *A. pratensis*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects ($P < 0.05$) are given in bold, marginally significant effects ($P < 0.1$) in italics.

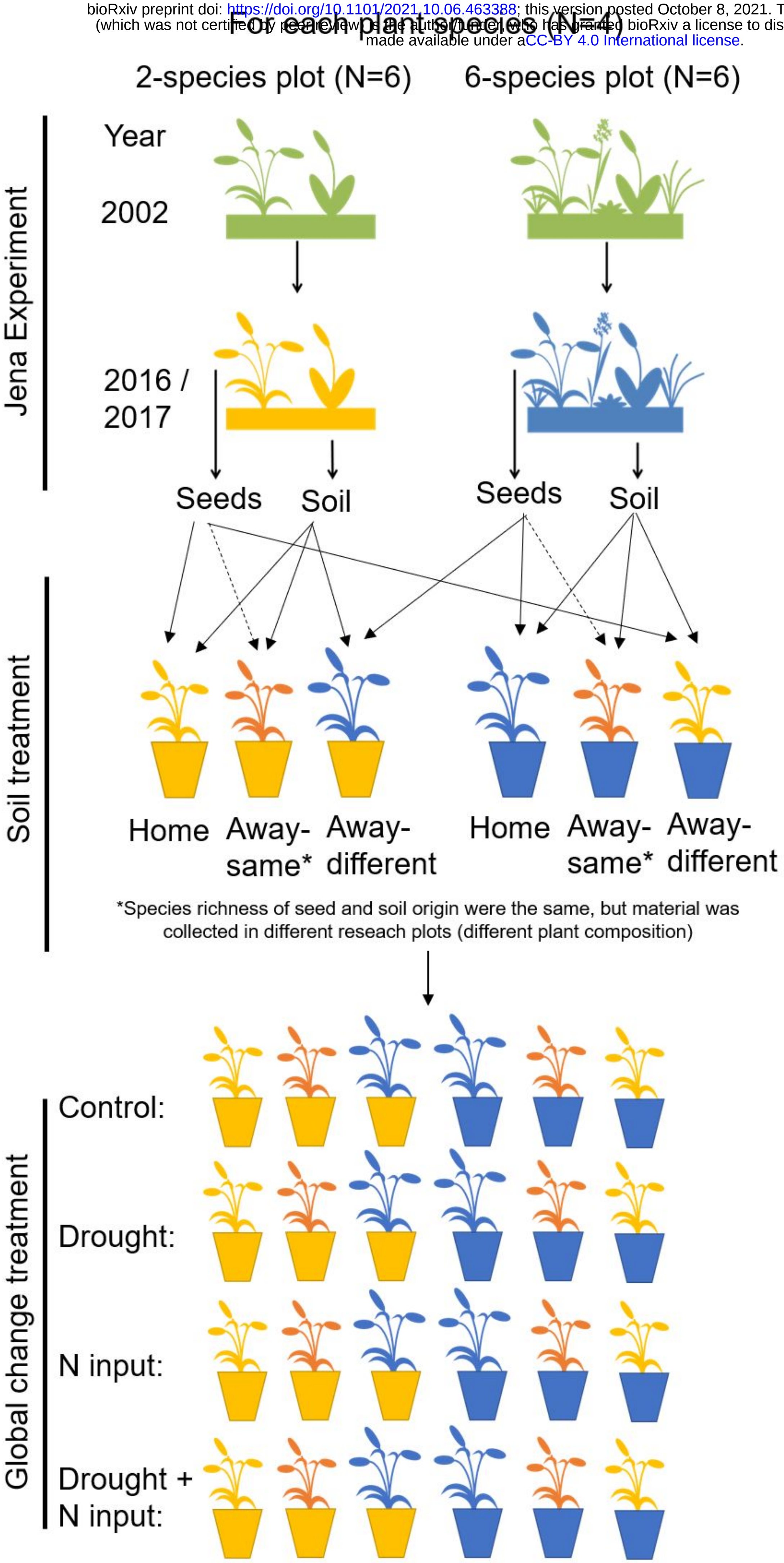
A. pratensis	Total biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.05	0.820	1	0.27	0.603	1	1.63	0.202	1	1.44	0.230
Soil history	1	0.02	0.879	1	1.05	0.306	1	2.97	*0.085*	1	2.07	0.151
Soil treatment	2	3.43	0.180	2	0.17	0.917	2	1.29	0.525	2	2.80	0.247
	Shoot biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.11	0.741	1	0.29	0.590	1	0.65	0.421	1	2.23	0.135
Soil history	1	0.14	0.710	1	0.33	0.564	1	0.86	0.354	1	<0.01	0.971
Soil treatment	2	0.15	0.927	2	1.84	0.398	2	1.03	0.596	2	1.35	0.509
	Root biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.13	0.719	1	0.23	0.629	1	0.97	0.324	1	0.47	0.495
Soil history	1	0.15	0.703	1	1.16	0.281	1	1.83	0.176	1	3.98	**0.046**
Soil treatment	2	2.78	0.250	2	1.38	0.501	2	0.47	0.789	2	3.16	0.206
	Root-shoot ratio											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.13	0.719	1	0.01	0.920	1	0.30	0.584	1	0.90	0.342
Soil history	1	0.20	0.654	1	0.31	0.579	1	0.42	0.517	1	4.57	**0.033**
Soil treatment	2	1.33	0.514	2	4.94	*0.084*	2	0.04	0.982	2	0.37	0.832

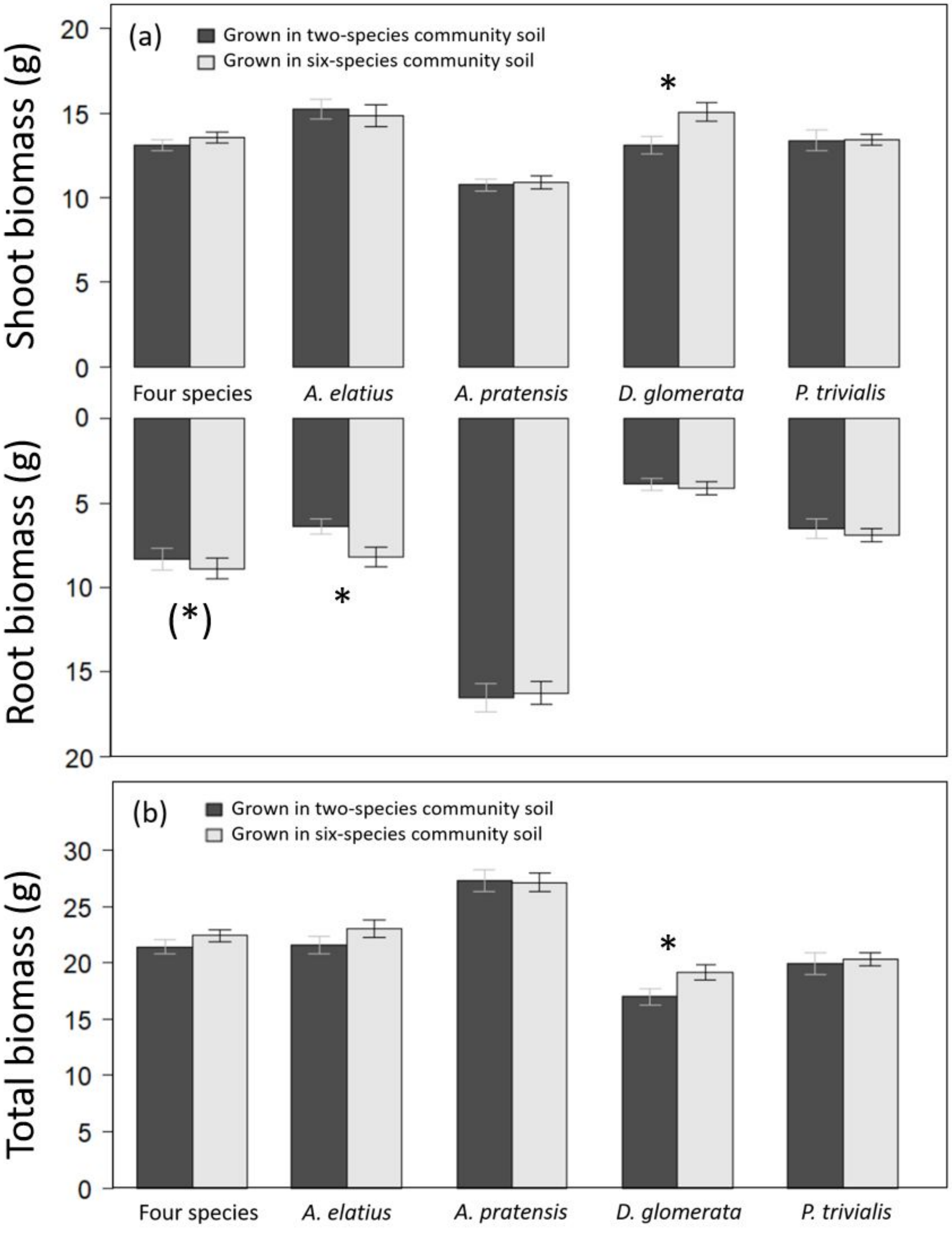
Table S10 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio) of *D. glomerata*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

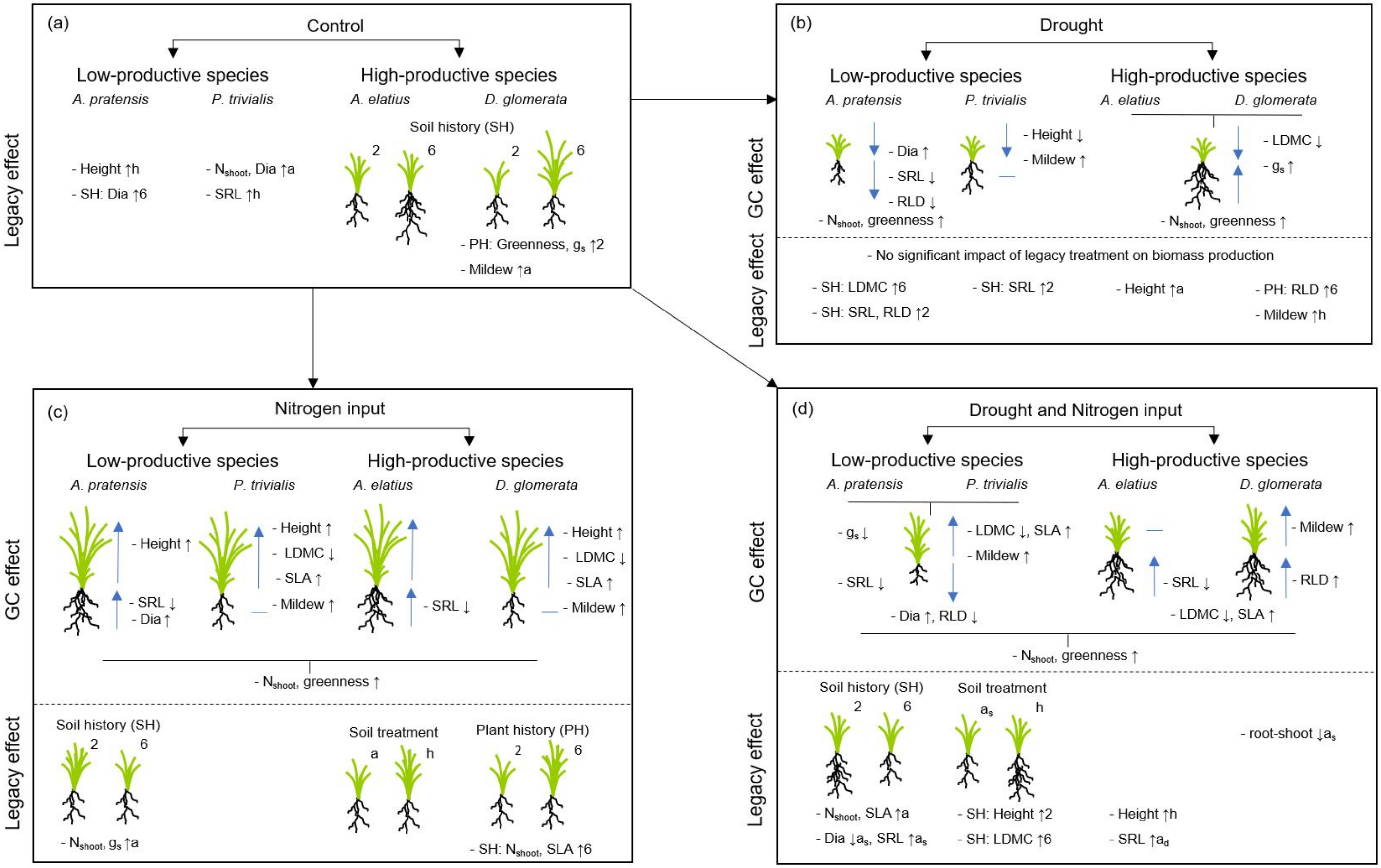
D. glomerata						Total biomass						
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.56	0.456	1	2.22	0.136	1	3.09	*0.079*	1	0.13	0.715
Soil history	1	6.28	**0.012**	1	0.76	0.384	1	0.73	0.394	1	<0.01	0.978
Soil treatment	2	1.52	0.467	2	0.94	0.626	2	1.26	0.533	2	0.73	0.693
						Shoot biomass						
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.02	0.885	1	1.28	0.259	1	3.18	*0.075*	1	0.22	0.640
Soil history	1	8.27	**0.004**	1	0.81	0.369	1	0.33	0.567	1	0.15	0.700
Soil treatment	2	3.06	0.216	2	0.44	0.801	2	3.34	0.188	2	0.14	0.932
						Root biomass						
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.40	0.236	1	2.55	0.111	1	1.98	0.160	1	0.04	0.848
Soil history	1	0.90	0.343	1	0.45	0.501	1	0.99	0.319	1	0.21	0.644
Soil treatment	2	2.49	0.288	2	2.06	0.358	2	0.02	0.992	2	3.16	0.206
						Root-shoot ratio						
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	1.65	0.199	1	1.71	0.191	1	0.93	0.335	1	0.01	0.936
Soil history	1	<0.01	0.983	1	0.44	0.505	1	0.43	0.514	1	0.75	0.387
Soil treatment	2	3.14	0.208	2	2.84	0.242	2	0.20	0.906	2	7.72	**0.021**

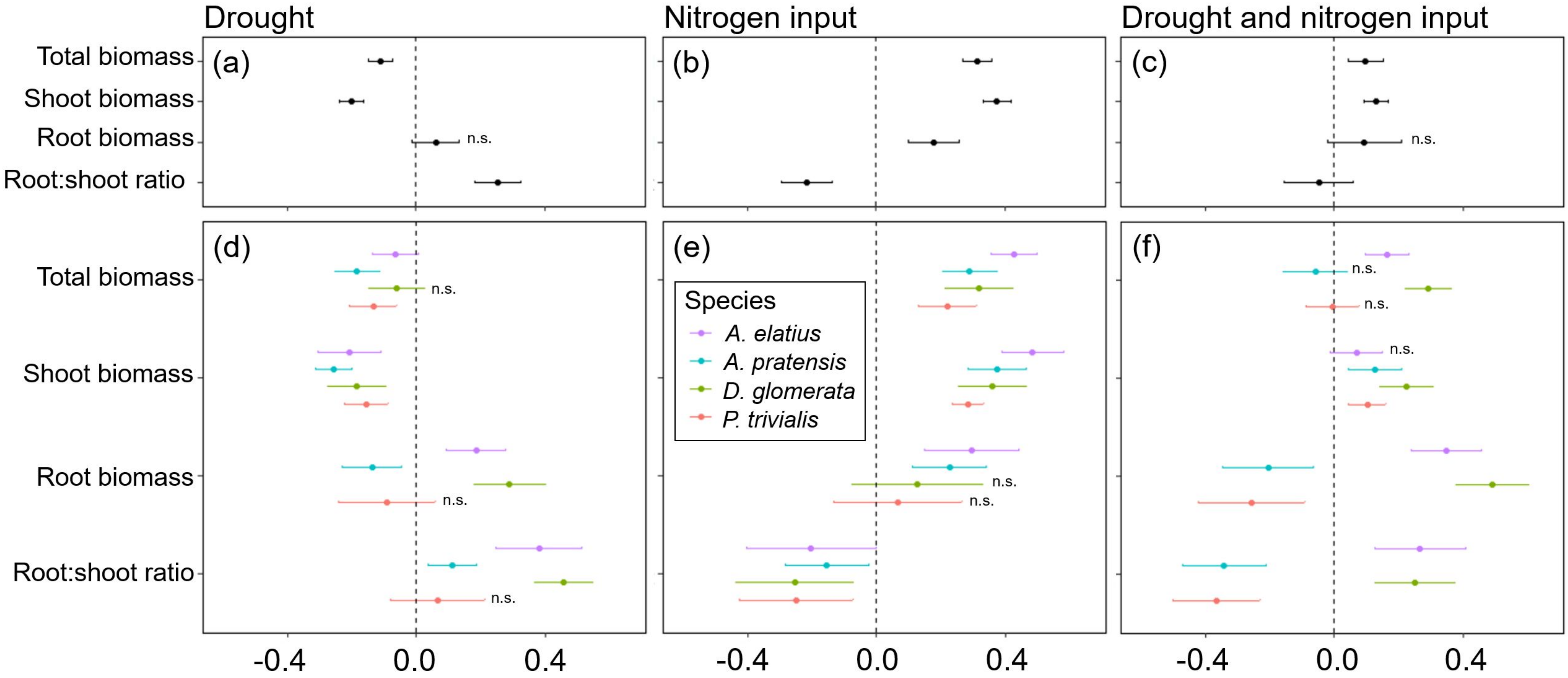
Table S11 Summary of mixed-effect model analyses testing the effects of legacy treatments (plant history, soil history, soil treatment) on plant performance (total biomass, shoot biomass, root biomass and root-shoot ratio) of *P. trivialis*, when non-treated (control) or treated with GC drivers (drought, nitrogen input, drought and nitrogen input (D x N)). Shown are degrees of freedom (Df), Chi^2 and P-values (P). Significant effects (P < 0.05) are given in bold, marginally significant effects (P < 0.1) in italics.

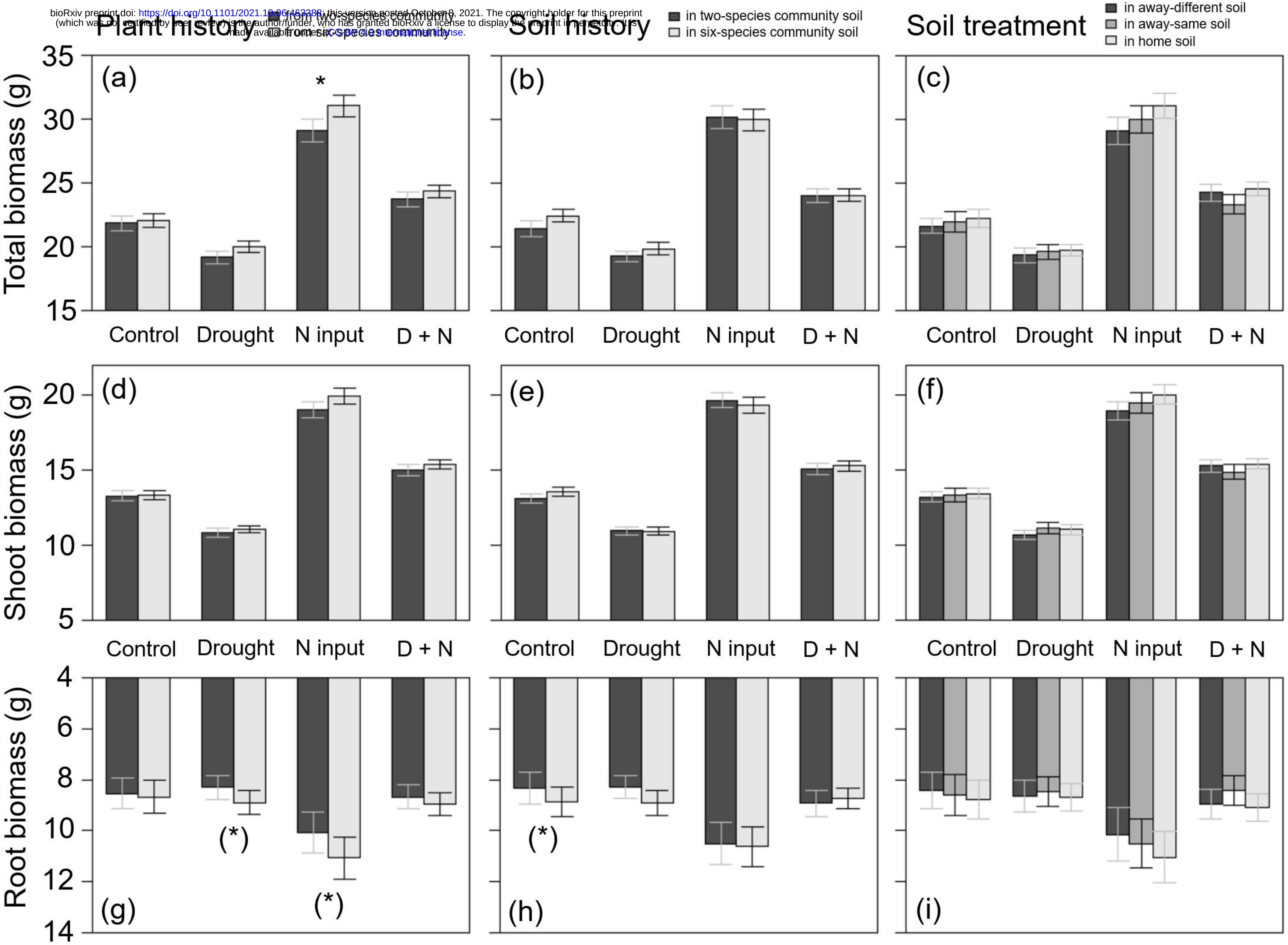
P. trivialis	Total biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.12	0.732	1	1.25	0.264	1	0.28	0.599	1	0.43	0.513
Soil history	1	0.12	0.731	1	0.14	0.704	1	0.07	0.796	1	0.05	0.826
Soil treatment	2	0.01	0.995	2	1.82	0.404	2	1.69	0.430	2	4.06	0.131
	Shoot biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.01	0.920	1	1.91	0.167	1	0.39	0.532	1	0.01	0.943
Soil history	1	<0.01	0.973	1	0.47	0.492	1	0.46	0.499	1	0.19	0.663
Soil treatment	2	1.34	0.511	2	0.81	0.667	2	1.22	0.545	2	2.96	0.227
	Root biomass											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.21	0.647	1	0.66	0.417	1	1.48	0.224	1	1.45	0.229
Soil history	1	0.33	0.566	1	1.24	0.266	1	0.74	0.389	1	0.03	0.870
Soil treatment	2	1.36	0.506	2	1.10	0.577	2	1.99	0.370	2	5.03	*0.081*
	Root-shoot ratio											
	Control			Drought			Nitrogen			D x N		
	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P	Df	Chi^2	P
Plant history	1	0.23	0.630	1	0.14	0.708	1	2.00	0.158	1	2.25	0.134
Soil history	1	0.23	0.630	1	3.19	*0.074*	1	1.57	0.211	1	0.15	0.697
Soil treatment	2	3.61	0.164	2	0.68	0.711	2	2.16	0.340	2	5.12	*0.077*


For each plant species (N=4)
2-species plot (N=6)
6-species plot (N=6)
Jena Experiment
Year
2002
2016 / 2017
Seeds
Soil
Seeds
Soil
Soil treatment
Home
Away-same*
Away-different
Home
Away-same*
Away-different
*Species richness of seed and soil origin were the same, but material was collected in different reseach plots (different plant composition)
Global change treatment
Control:
Drought:
N input:
Drought + N input:


(a)
Grown in two-species community soil
Grown in six-species community soil
Shoot biomass (g)
20
15
10
5
0
*
Four species
A. elatius
A. pratensis
D. glomerata
P. trivialis
Root biomass (g)
0
5
10
15
20
(*)
*
(b)
Grown in two-species community soil
Grown in six-species community soil
Total biomass (g)
30
25
20
15
10
5
0
*
Four species
A. elatius
A. pratensis
D. glomerata
P. trivialis


(a)
Control
Legacy effect
Low-productive species
High-productive species
A. pratensis
P. trivialis
A. elatius
D. glomerata
Soil history (SH)
2
6
2
6
- Height ↑h
- SH: Dia ↑6
- N_{shoot}, Dia ↑a
- SRL ↑h
- PH: Greenness, g_s ↑2
- Mildew ↑a
(b)
Drought
GC effect
Legacy effect
Low-productive species
High-productive species
A. pratensis
P. trivialis
A. elatius
D. glomerata
- Dia ↑
- SRL ↓
- RLD ↓
- Height ↓
- Mildew ↑
- LDMC ↓
- g_s ↑
- N_{shoot}, greenness ↑
- N_{shoot}, greenness ↑
- No significant impact of legacy treatment on biomass production
- SH: LDMC ↑6
- SH: SRL, RLD ↑2
- SH: SRL ↑2
- Height ↑a
- PH: RLD ↑6
- Mildew ↑h
(c)
Nitrogen input
GC effect
Legacy effect
Low-productive species
High-productive species
A. pratensis
P. trivialis
A. elatius
D. glomerata
- Height ↑
- SRL ↓
- Dia ↑
- Height ↑
- LDMC ↓
- SLA ↑
- Mildew ↑
- SRL ↓
- Height ↑
- LDMC ↓
- SLA ↑
- Mildew ↑
- N_{shoot}, greenness ↑
Soil history (SH)
2
6
- N_{shoot}, g_s ↑a
Soil treatment
a
h
Plant history (PH)
2
6
- SH: N_{shoot}, SLA ↑6
(d)
Drought and Nitrogen input
GC effect
Legacy effect
Low-productive species
High-productive species
A. pratensis
P. trivialis
A. elatius
D. glomerata
- g_s ↓
- SRL ↓
- LDMC ↓, SLA ↑
- Mildew ↑
- Dia ↑, RLD ↓
- SRL ↓
- Mildew ↑
- RLD ↑
- LDMC ↓, SLA ↑
- N_{shoot}, greenness ↑
Soil history (SH)
2
6
Soil treatment
a_s
h
- root-shoot ↓a_s
- N_{shoot}, SLA ↑a
- Dia ↓a_s, SRL ↑a_s
- SH: Height ↑2
- SH: LDMC ↑6
- Height ↑h
- SRL ↑a_d


Drought
Nitrogen input
Drought and nitrogen input
(a)
(b)
(c)
(d)
(e)
(f)
Total biomass
Shoot biomass
Root biomass
Root:shoot ratio
n.s.
Species
A. elatius
A. pratensis
D. glomerata
P. trivialis
-0.4
0.0
0.4


Plant history
■ from two-species community
□ from six-species community
Soil history
■ in two-species community soil
□ in six-species community soil
Soil treatment
■ in away-different soil
▨ in away-same soil
□ in home soil
Total biomass (g)
35
30
25
20
15
(a)
(b)
(c)
*
Control
Drought
N input
D + N
Shoot biomass (g)
20
15
10
5
(d)
(e)
(f)
Root biomass (g)
4
6
8
10
12
14
(*)
(*)
(*)
(g)
(h)
(i)