**SUPPLEMENTAL MATERIAL for “Global response patterns of plant functional traits to combined nitrogen and phosphorus addition are governed by additive interactions”**

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**Text S1**

*Climate effects on plant responses to nitrogen addition*

Increasing growing season temperature decreased the response ratio that explained the effect of nitrogen addition on *N*mass (Fig. 4a; Table SX) and marginally decreased the ratio that explained the effect of nitrogen addition on *N*area, but did not modify *P*mass, *P*area, or *M*area responses to nitrogen addition (Table SX). While increasing temperature marginally decreased the response ratio that explained the effect of nitrogen addition on total biomass, temperature did not modify any other whole-plant trait response to nitrogen addition (Table SX). Increasing growing season aridity decreased the response ratio that explained the effect of nitrogen addition on *N*mass (Fig. 4b; Table SX) and marginally decreased the response ratio that explained the effect of nitrogen addition on *N*area( Table SX). Aridity did not modify any leaf phosphorus or whole-plant trait response to nitrogen addition (Table SX). Growing season light availability played no role in shaping leaf nutrient or whole-plant responses to nitrogen addition, except for marginally increasing the response ratio that explained the effect of nitrogen addition on root mass fraction (Table SX).

*Climate effects on plant responses to phosphorus addition*

Temperature did not modify the effects of phosphorus addition on *M*area, *N*mass or *N*area; however, increasing temperature decreased the response ratio that explained the effect of phosphorus addition on *P*mass (Fig. 4f; Table SX) and marginally decreased the ratio that explained the effect of phosphorus addition on *P*area (Table SX). Increasing temperature also marginally decreased the response ratio that explained the effect of phosphorus addition on total biomass, with no effect of temperature on any other whole-plant trait response to phosphorus addition (Table SX).

Increasing growing season aridity marginally decreased the response ratio that explained the effect of phosphorus addition on *P*mass (Fig. 4g) and significantly increased the response ratio that explained the effect of phosphorus addition on *M*area (Table SX). There was no effect of growing season aridity on *N*mass, *N*area, or *P*area responses to phosphorus addition (Table SX). Increasing growing season aridity increased the response ratio that explained the effect of phosphorus addition on aboveground biomass and decreased the response ratio that explained the effect of phosphorus addition on the root:shoot ratio, but there was no effect of aridity on any other whole-plant trait response to phosphorus addition (Table SX).

Growing season light availability played no role in shaping leaf nutrient or whole-plant response to phosphorus addition (Table SX).

*Climate effects on plant responses to nitrogen and phosphorus addition*

Increasing temperature increased the response ratio that explained the effect of nitrogen+ phosphorus addition on *M*area and decreased the response ratio that explained the effect of nitrogen+phosphorus addition on *N*mass (Table SX). Temperature did not modify *N*area, *P*mass, or *P*area responses to nitrogen+phosphorus addition (Table SX). Increasing temperature marginally decreased the response ratio that explained the effect of nitrogen+phosphorus addition on total biomass; however, temperature did not modify any other whole-plant trait response to nitrogen+phosphorus addition (Table SX).

Increasing growing season aridity increased the response ratio that explained the effect of nitrogen+phosphorus addition on *M*area and decreased the response ratio that explained the effect of nitrogen+phosphorus addition on *P*mass (Table SX). There was no effect of aridity on any other leaf nutrient trait response to nitrogen+phosphorus addition (Table SX). Growing season aridity did not modify any whole-plant trait response to nitrogen+phosphorus addition (Table SX).

Increasing growing season light availability increased the response ratio that explained the effect of nitrogen+phosphorus addition on *P*area, but light availability did not modify any other leaf nutrient response to nitrogen+phosphorus addition (Table SX). Increasing growing season light availability also increased the response ratio that explained the effect of nitrogen+phosphorus addition on belowground biomass, but there was no effect of light availability on any other whole-plant trait (Table SX).

*Species identity moderator effects*

Species significantly modified plant responses to nutrient additions (Table SX). For example, non-fixing species generally exhibited significantly stronger leaf nitrogen content responses to nitrogen addition than N2-fixing species (Table SX) and scavenging mycorrhizal species generally exhibited significantly stronger leaf phosphorus content responses to phosphorus addition (Table SX). All species moderator effects are summarized in Tables SX.

**Table S1** Summary of studies and sites included in the meta-analysis\*

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Aerts *et al.*, 2003) | bovenpolder | 51.85 | 5.62 | 6 | 9.6 | 1.56 | 478 | grassland | field | 10 | 5 |
| bethunepolder | 52.07 | 5.58 | 8 | 9.7 | 1.81 | 474 | grassland | field | 10 | 5 |
| (Arens *et al.*, 2008) | pituffik | 76.55 | -68.57 | 229 | 4.2 | 0.25 | 855 | tundra | field | 5 | 2.5 |
| (Augustine *et al.*, 2003) | mpala\_ranch | 0.28 | 37.88 | 1775 | 18.6 | 1.29 | 868 | grassland | field | 40 | 10 |
| (Aydin & Uzun, 2005) | ondokuz | 41.35 | 36.25 | 4 | 14.1 | 0.75 | 698 | grassland | field | 18 | 5.2 |
| (Bennett & Adams, 2001) | hamersley | -22.28 | 117.67 | 606 | 24.5 | 0.13 | 1078 | grassland | field | 5 | 2.5 |
| (Blanke *et al.*, 2012) | alpflix | 46.53 | 9.65 | 2029 | 6.6 | 1.45 | 836 | grassland | field | 5 | 6 |
| (Boeye *et al.*, 1997) | buitengoor | 51.20 | 5.17 | 36 | 10.3 | 1.46 | 481 | wetland | field | 20 | 5 |
| goorken | 51.32 | 5.12 | 27 | 10.1 | 1.51 | 480 | wetland | field | 20 | 5 |
| zwarte\_beek | 51.08 | 5.30 | 56 | 10.1 | 1.55 | 483 | wetland | field | 20 | 5 |
| (Borer *et al.*, 2014) | sedgwick | 34.7 | -119.88 | 1122 | 12.8 | 0.49 | 883 | grassland | field | 10 | 10 |
| (Bowman *et al.*, 1993) | niwot\_ridge | 40.06 | -105.58 | 3471 | 6.1 | 0.40 | 967 | tundra | field | 25 | 25 |
| (Bown *et al.*, 2007) | purokohukohu | NA | NA | NA | NA | NA | NA | NA | pot | 7.14 (mM) | 0.42 (mM) |
| (Cárate-Tandalla *et al.*, 2018) | bombuscaro | -4.12 | -78.97 | 1163 | 22.4 | 1.08 | 651 | forest | field | 5 | 1 |
| cajanuma | -4.12 | -79.18 | 2511 | 14.4 | 1.01 | 684 | forest | field | 5 | 1 |
| sanfrancisco | -3.97 | -79.18 | 2163 | 16.2 | 0.80 | 660 | forest | field | 5 | 1 |
| (Carswell *et al.*, 2005) | okarito | -43.20 | 170.30 | NA | NA | NA | NA | NA | pot | 5 (mM) | 1.33 (mM) |
| (Chen *et al.*, 2020) | zhifanggou | 36.74 | 109.25 | 1221 |  |  |  | grassland | field | 10 | 8 |

**Table S1 (cont.)**

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| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Cleland *et al.*, 2019) | bldr.us | 39.97 | -105.23 | 1649 | 11.0 | 0.30 | 830 | grassland | field | 10 | 10 |
| bnch.us | 44.28 | -121.97 | 1298 | 7.8 | 1.71 | 770 | grassland | field | 10 | 10 |
| bogong.au | -36.87 | 147.24 | 1567 | 7.3 | 2.09 | 797 | grassland | field | 10 | 10 |
| burrawan.au | -27.73 | 151.14 | 411 | 18.2 | 0.34 | 897 | grassland | field | 10 | 10 |
| cbgb.us | 41.79 | -93.39 | 275 | 14.1 | 0.74 | 785 | grassland | field | 10 | 10 |
| cdcr.us | 45.40 | -93.2 | 282 | 15.1 | 0.67 | 826 | grassland | field | 10 | 10 |
| cdpt.us | 41.2 | -101.63 | 1018 | 13.8 | 0.28 | 874 | grassland | field | 10 | 10 |
| cowi.ca | 48.46 | -123.38 | 24 | 10.5 | 1.91 | 561 | grassland | field | 10 | 10 |
| elliot.us | 32.88 | -117.05 | 256 | 17.7 | 0.25 | 880 | grassland | field | 10 | 10 |
| frue.ch | 47.11 | 8.54 | 972 | 7.8 | 2.13 | 617 | grassland | field | 10 | 10 |
| gilb.za | -29.28 | 30.29 | 1666 | 13.9 | 0.59 | 855 | grassland | field | 10 | 10 |
| hall.us | 36.87 | -86.7 | 201 | 13.7 | 1.27 | 709 | grassland | field | 10 | 10 |
| hart.us | 42.72 | -119.5 | 1513 | 9.5 | 0.20 | 866 | grassland | field | 10 | 10 |
| konz.us | 39.07 | -96.58 | 421 | 15.0 | 0.58 | 817 | grassland | field | 10 | 10 |
| lancaster.uk | 53.99 | -2.63 | 219 | 8.0 | 3.37 | 443 | grassland | field | 10 | 10 |
| look.us | 44.21 | -122.13 | 1481 | 6.1 | 2.72 | 673 | grassland | field | 10 | 10 |
| mtca.au | -31.78 | 117.61 | 297 | 17.7 | 0.24 | 957 | grassland | field | 10 | 10 |
| sage.us | 39.43 | -120.24 | 1968 | 8.5 | 0.53 | 977 | grassland | field | 10 | 10 |
| saline.us | 39.05 | -99.1 | 566 | 14.9 | 0.35 | 858 | grassland | field | 10 | 10 |
| sgs.us | 40.82 | -104.77 | 1654 | 11.2 | 0.22 | 860 | grassland | field | 10 | 10 |
| shps.us | 44.24 | -112.2 | 1667 | 12.2 | 0.15 | 963 | grassland | field | 10 | 10 |
| sier.us | 39.24 | -121.28 | 258 | 16.3 | 1.06 | 820 | grassland | field | 10 | 10 |
| smith.us | 48.21 | -122.62 | 56 | 10.2 | 1.08 | 562 | grassland | field | 10 | 10 |
| spin.us | 38.14 | -84.5 | 284 | 13.6 | 1.07 | 718 | grassland | field | 10 | 10 |
| summ.za | -29.81 | 30.72 | 636 | 18.2 | 0.59 | 810 | grassland | field | 10 | 10 |
| trel.us | 40.08 | -88.83 | 215 | 15.4 | 0.82 | 784 | grassland | field | 10 | 10 |
| ukul.za | -29.67 | 30.4 | 810 | 17.6 | 0.50 | 831 | grassland | field | 10 | 10 |
| unc.us | 36.01 | -79.02 | 147 | 14.9 | 0.94 | 734 | grassland | field | 10 | 10 |
| valm.ch | 46.63 | 10.37 | 2233 | 5.5 | 0.80 | 827 | grassland | field | 10 | 10 |
| (Craft *et al.*, 1995) | everglades | 26.38 | -80.46 | 5 | 23.4 | 0.79 | 860 | grassland | field | 22.4 | 4.8 |
| (Craine *et al.*, 2008) | pretoriuskop | -25.13 | 31.23 | 569 | 20.9 | 0.39 | 861 | grassland | field | 10 | 5 |
| letaba | -23.76 | 31.43 | 270 | 22.7 | 0.24 | 870 | grassland | field | 10 | 5 |
| makhohlola | -25.30 | 31.91 | 198 | 22.3 | 0.33 | 820 | grassland | field | 10 | 5 |
| satara | -24.40 | 31.75 | 299 | 22.0 | 0.31 | 847 | grassland | field | 10 | 5 |
| nwashitsumbe | -22.78 | 31.25 | 386 | 23.1 | 0.25 | 890 | grassland | field | 10 | 5 |
| (Crous *et al.*, 2017) | ANUglass | NA | NA | NA | NA | NA | NA | NA | pot | 3.3 (g yr-1) | 0.153 (g yr-1) |
| (Cunha *et al.*, 2024) | londrina | -23.32 | -51.18 | NA | NA | NA | NA | NA | pot | 8.4 | 4.5 |
| (D’Antonio & Mack, 2006) | volcanoNP | 19.1 | -155.55 | 148 | 22.8 | 0.95 | 860 | forest | field | 10 | 10 |

**Table S1 (cont.)**

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| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Davidson *et al.*, 2004) | fazendaVitoria | -2.98 | -47.52 | 136 | 25.9 | 1.62 | 771 | forest | field | 10 | 5 |
| (Dong *et al.*, 2016) | baingoin | 31.43 | 90.03 | 4705 | 6.4 | 0.52 | 931 | grassland | field | 15 | 12.9 |
| (Eller *et al.*, 2017) | flottbek | 53.56 | 9.86 | NA | NA | NA | NA | NA | pot | 1.3 (g pot-1) | 1.3 (g pot-1) |
| (Falk *et al.*, 2010) | luneberg | 53.25 | 9.97 | 118 | 8.5 | 1.76 | 469 | grassland | field | 5 | 2 |
| (Fisher *et al.*, 2013) | tambopata | -12.84 | -69.30 | 198 | 25.3 | 1.83 | 709 | forest | field | 2.5 | 0.5 |
| tono | -12.95 | -71.53 | 805 | 23.1 | 2.04 | 726 | forest | field | 2.5 | 0.5 |
| san\_pedro | -13.05 | -71.54 | 1511 | 20.2 | 1.68 | 674 | forest | field | 2.5 | 0.5 |
| wayqecha | -13.19 | -71.59 | 2989 | 12.9 | 0.29 | 683 | forest | field | 2.5 | 0.5 |
| (Firn *et al.*, 2019) | bogong.au | -36.87 | 147.24 | 1567 | 7.3 | 2.09 | 797 | grassland | field | 10 | 10 |
| burrawan.au | -27.73 | 151.14 | 411 | 18.2 | 0.34 | 897 | grassland | field | 10 | 10 |
| cbgb.us | 41.79 | -93.39 | 275 | 14.1 | 0.74 | 785 | grassland | field | 10 | 10 |
| cowi.ca | 48.46 | -123.38 | 24 | 10.5 | 1.91 | 561 | grassland | field | 10 | 10 |
| elliot.us | 32.88 | -117.05 | 256 | 17.7 | 0.25 | 880 | grassland | field | 10 | 10 |
| frue.ch | 47.11 | 8.54 | 972 | 7.8 | 2.13 | 617 | grassland | field | 10 | 10 |
| gilb.za | -29.28 | 30.29 | 1666 | 13.9 | 0.59 | 855 | grassland | field | 10 | 10 |
| kiny.au | -36.20 | 143.75 | 99 | 15.5 | 0.33 | 809 | grassland | field | 10 | 10 |
| konz.us | 39.07 | -96.58 | 421 | 15.0 | 0.58 | 817 | grassland | field | 10 | 10 |
| lancaster.uk | 53.99 | -2.63 | 219 | 8.0 | 3.37 | 443 | grassland | field | 10 | 10 |
| look.us | 44.21 | -122.13 | 1481 | 6.1 | 2.72 | 673 | grassland | field | 10 | 10 |
| mcla.us | 38.86 | -122.41 | 647 | 14.0 | 1.15 | 803 | grassland | field | 10 | 10 |
| mtca.au | -31.78 | 117.61 | 297 | 17.7 | 0.24 | 957 | grassland | field | 10 | 10 |
| saline.us | 39.05 | -99.10 | 566 | 14.9 | 0.35 | 858 | grassland | field | 10 | 10 |
| sgs.us | 40.82 | -104.77 | 1654 | 11.2 | 0.22 | 860 | grassland | field | 10 | 10 |
| shps.us | 44.24 | -112.2 | 1667 | 12.2 | 0.15 | 963 | grassland | field | 10 | 10 |
| smith.us | 48.21 | -122.62 | 56 | 10.2 | 1.08 | 562 | grassland | field | 10 | 10 |
| summ.za | -29.81 | 30.72 | 636 | 18.2 | 0.59 | 810 | grassland | field | 10 | 10 |
| valm.ch | 46.63 | 10.37 | 2233 | 5.5 | 0.80 | 827 | grassland | field | 10 | 10 |
| (Fornara *et al.*, 2013) | nash | 51.41 | -0.64 | 61 | 10.2 | 1.25 | 478 | grassland | field | 10 | 3.5 |
| (Friedrich *et al.*, 2012) | luneberggh2 | 53.25 | 9.97 | NA | NA | NA | NA | NA | pot | 4.8 | 0.4 |
| (Frost *et al.*, 2009) | hammersmith | 31.30 | -81.28 | 2 | 19.7 | 0.86 | 801 | wetland | field | 50 | 10 |
| (Gough & Hobbie, 2003) | toolik\_nonacidic | 68.63 | -149.72 | 726 | 6.8 | 0.52 | 592 | tundra | field | 10 | 5 |
| (Güsewell *et al.*, 2002) | vechtplassen | 52.50 | 5.70 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| (Güsewell *et al.*, 2003) | gusewellS1 | 51.70 | 3.90 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellS2 | 51.70 | 3.90 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellV1 | 51.7 | 3.9 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellV2 | 51.7 | 3.9 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellV3 | 51.7 | 3.9 | -2 | 10.2 | 1.42 | 493 | wetland | field | 20 | 5 |
| gusewellT1 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellT2 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |

**Table S1 (cont.)**

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| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Güsewell *et al.*, 2003) | gusewellW1 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellW2 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellW3 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| gusewellW4 | 52.5 | 5.7 | -5 | 9.8 | 1.58 | 471 | wetland | field | 20 | 5 |
| (Haag, 1974) | tuktoyaktuk | 69.43 | -133.02 | 1 | 7.5 | 0.36 | 712 | tundra | field | 10 | 10 |
| (Han *et al.*, 2011) | seefs\_sunny | 38.79 | 110.35 | 1230 | 14.2 | 0.30 | 948 | grassland | field | 10 | 10 |
| (Harrington *et al.*, 2001) | volcanoNP | 19.10 | -155.55 | 148 | 22.8 | 0.95 | 860 | forest | field | 10 | 10 |
| naPaliKona | 22.13 | -159.63 | 1056 | 15.7 | 1.27 | 879 | forest | field | 10 | 10 |
| (Haubensak & D’Antonio, 2011) | ggnra | 37.87 | -122.52 | 87 | 14.1 | 1.18 | 793 | grassland | field | 10 | 10 |
| (He *et al.*, 2016) | haibei | 37.62 | 101.2 | 3157 | 6.2 | 0.52 | 930 | grassland | field | 10 | 5 |
| (Herbert & Fownes, 1995) | naPaliKona | 22.13 | -159.63 | 1056 | 15.7 | 1.27 | 879 | forest | field | 10 | 10 |
| (Hersch-Green *et al.*, 2024) | kbs.us | 42.41 | -85.39 | 289 | 13.0 | 0.86 | 739 | grassland | field | 10 | 10 |
| konz.us | 39.07 | -96.58 | 421 | 15.0 | 0.58 | 817 | grassland | field | 10 | 10 |
| spin.us | 38.14 | -84.50 | 284 | 13.6 | 1.07 | 718 | grassland | field | 10 | 10 |
| (Huff *et al.*, 2015) | tifft | 42.87 | -78.87 | 178 | 12.5 | 0.97 | 729 | grassland | field | 10 | 8.6 |
| (Iversen *et al.*, 2010) | undercBog | 46 | -89 | 523 | 12.1 | 0.85 | 799 | wetland | field | 6 | 2 |
| undercRichFen | 46 | -89 | 523 | 12.1 | 0.85 | 799 | wetland | field | 6 | 2 |
| (Jing *et al.*, 2016) | haibeiAGERS | 37.6 | 101.32 | 3311 | 5.6 | 0.54 | 927 | grassland | field | 10 | 5 |
| (Ket *et al.*, 2011) | altamaha | 31.33 | -81.47 | 6 | 19.6 | 0.85 | 795 | wetland | field | 50 | 10 |
| (Lawrence, 2001) | kembera | 0.12 | 110.5 | 133 | 26.4 | 2.15 | 773 | forest | field | 54 | 60 |
| (Li *et al.*, 2011) | daqinggou | 42.97 | 122.35 | 249 | 16.8 | 0.41 | 912 | grassland | field | 20 | 10 |
| (Li *et al.*, 2014) | amwelu | 34.92 | 102.88 | 3213 | 7.5 | 0.76 | 822 | grassland | field | 10 | 10 |
| (Ludwig *et al.*, 2001) | tarangire | -3.5 | 36 | 1045 | 22.0 | 0.40 | 792 | grassland | field | 20 | 8 |
| (Lund *et al.*, 2009) | fajemyr | 56.25 | 13.55 | 141 | 8.3 | 2.22 | 544 | wetland | field | 4 | 0.4 |
| (Mayor *et al.*, 2014) | gigante | 9.11 | -79.84 | 83 | 26.4 | 1.38 | 939 | forest | field | 12.5 | 5 |
| (McMaster *et al.*, 1982) | echoValley | 32.9 | 70 | 1472 | 17.2 | 0.31 | 874 | shrubland | field | 4 | 2 |
| (Mo *et al.*, 2019) | xiaolongRS | 21.45 | 110.9 | 27 | 23.3 | 1.11 | 794 | forest | field | 10 | 10 |
| (Mo *et al.*, 2021) | xiaoliangRS | 21.45 | 110.9 | 27 | 23.3 | 1.11 | 794 | forest | field | 10 | 10 |
| (Ngai & Jefferies, 2004) | laPerouse | 58.744 | -93.601 | 6 | 9.8 | 0.69 | 799 | wetland | field | 17 | 12 |
| (Ngatia *et al.*, 2015) | mpala | 0 | 37 | 1852 | 16.5 | 0.52 | 852 | grassland | field | 10 | 5 |
| (Nielsen *et al.*, 2009) | brandbjerg | 55.88 | 11.97 | 9 | 9.7 | 1.67 | 551 | grassland | field | 7.5 | 1 |
| (O’Halloran *et al.*, 2010) | tshane | -24.17 | 21.89 | 1117 | 21.3 | 0.12 | 1067 | grassland | field | 6.7 | 3.3 |
| (Øien, 2004) | solendet | 62.67 | 11.83 | 696 | 7.1 | 1.42 | 631 | wetland | field | 12 | 3 |
| (Prystupa *et al.*, 2004) | uniBueAi | -34.58 | -58.48 | 23 | 17.4 | 0.73 | 777 | cropland | field | 10 | 5.7 |
| (Rejmánková *et al.*, 2008) | belize | 18.83 | -89.12 | 103 | 25.1 | 0.54 | 880 | wetland | field | 20 | 10 |
| (Ren *et al.*, 2010) | lanzhou | 33.97 | 101.88 | 3646 | 5.7 | 0.91 | 805 | grassland | field | 10 | 20 |
| (Ries & Shugart, 2008) | pandamatenga | -18.66 | 25.5 | 1082 | 23.5 | 0.26 | 974 | grassland | field | 20 | 10 |
| (Scott *et al.*, 2015) | ruakura | -37.78 | 175.32 | 46 | 14.2 | 1.35 | 723 | grassland | field | 10 | 3.15 |

**Table S1 (cont.)**

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| **Citation** | **Site name** | **Latitude** | **Longitude** | **Elevation** | ***T*g** | ***AI*g** | ***PAR*g** | **Ecosystem type** | **Experiment type** | **N addition rate (g m-2)** | **P addition rate (g m-2)** |
| (Shaver *et al.*, 1998) | toolik\_inlet | 68.63 | -149.57 | 768 | 6.6 | 0.53 | 590 | tundra | field | 10 |  |
| toolik\_sag | 68.77 | -148.87 | 452 | 7.7 | 0.49 | 592 | tundra | field | 10 |  |
| (Soudzilovskaia *et al.*, 2005) | teberda | 48.45 | 41.7 | 86 | 14.0 | 0.47 | 705 | tundra | field | 9 | 2.5 |
| (Sun *et al.*, 2022) | shihezi | 44.33 | 86.5 |  |  |  |  |  | field | 12 | 5 |
| (Tischer *et al.*, 2015) | cordillera | -3.97 | -70.07 | 127 | 26.5 | 2.53 | 644 | grassland | field | 5 | 1 |
| (van Cleve & Oliver, 1982) | fairbanks | 64.83 | -147.72 | 132 | 12.3 | 0.39 | 688 | forest | field | 11.1 | 5.5 |
| (van der Hoek *et al.*, 2004) | bennekomse | 52.02 | 5.6 | 6 | 9.8 | 1.61 | 473 | grassland | field | 20 | 4 |
| (van der Waal *et al.*, 2011) | klaserie | -24.22 | 31.27 | 402 | 22.3 | 0.31 | 870 | grassland | field | 30 | 25 |
| (van Duren *et al.*, 1997a) | hasselt | 57 | 7 | 32 | 10.6 | 1.41 | 465 | grassland | field | 20 | 8 |
| (van Duren *et al.*, 1997b) | drentsche | 53.08 | 6.67 | 10 | 9.0 | 1.86 | 475 | grassland | field | 20 | 8 |
| (van Wijnen & Bakker, 1999) | schiermonikoog | 53.5 | 6.17 | 6 | 9.0 | 2.08 | 475 | wetland | field | 25 | 10 |
| (Verlinden *et al.*, 2018) | katelijne | 51.08 | 4.53 | NA | NA | NA | NA | NA | mesocosm | 9.5 | 2 |
| (Verryckt *et al.*, 2022) | nouragues | 4.00 | -52.60 | 57 | 25.8 | 2.06 | 887 | forest | field | 12.5 | 5 |
| (Wang *et al.*, 2017) | huitong | 26.67 | 109.43 | 519 | 16.1 | 1.20 | 633 | forest | field | 20 | 5 |
| (Wang *et al.*, 2018) | haibeiAMERS | 37.617 | 101.2 | 3157 | 6.2 | 0.52 | 930 | tundra | field | 10 | 5 |
| (Wang *et al.*, 2019) | qianyanzhou | 26.70 | 105.10 | 1913 | 12.2 | 0.93 | 617 | forest | field | 10 | 5 |
| (Warren & Adams, 2002) | bullsbrook | -31.67 | 116.02 | 40 | 18.8 | 0.51 | 977 | forest | field | 2 (mM) | 0.34 (mM) |
| (Wigand *et al.*, 2004) | nags\_creek | 41.63 | -71.32 | -16 | 12.3 | 1.17 | 710 | wetland | field | 32 | 3.2 |
| (Wright *et al.*, 2011) | barro | 9.12 | -79.85 | 56 | 26.5 | 1.41 | 938 | forest | field | 12.5 | 5 |
| (Yang *et al.*, 2014) | haibei | 38.297 | 101.337 | NA | NA | NA | NA | grassland | field | 10 | 5 |
| (Ye *et al.*, 2022) | jiulianshan\_RS | 24.49 | 114.38 | 624 | 18.1 | 1.49 | 680 | forest | field | 10 | 5 |
| (Ye *et al.*, 2023) | jiulianshan | 24.49 | 114.38 | 624 | 18.1 | 1.49 | 680 | forest | field | 10 | 5 |
| (Yu *et al.*, 2009) | daqinguo | 42.97 | 122.35 | 249 | 16.8 | 0.41 | 912 | grassland | field | 20 | 10 |
| (Yu *et al.*, 2015) | ewenke | 48.5 | 119.7 | 709 | 11.0 | 0.34 | 877 | grassland | field | 10 | 5 |
| (Yu *et al.*, 2022) | primary | 18.73 | 108.90 | 901 | 20.6 | 1.02 | 832 | forest | field | 10 | 10 |
| secondary | 18.74 | 108.86 | 845 | 20.9 | 1.03 | 833 | forest | field | 10 | 10 |
| (Zeng & Wang, 2015) | saihanba | 42.42 | 117.35 | 1684 | 9.7 | 0.46 | 924 | forest | field | 5 | 5 |

**\***Key: *T*g=1970-2000 growing season temperature (°C), *AI*g=growing season aridity index (unitless), *PAR*g=growing season photosynthetically active radiation (μmol m-2 s-1)

**Table S2** Meta-analytic results summarizing the effects of N, P, and N+P on traits related to leaf chemistry\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient addition** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *M*area | N | 113 | **-0.037±0.016** | **-2.318** | **0.020** | **[-0.068, -0.006]** |
| P | -0.015±0.015 | -1.019 | 0.308 | [-0.044, 0.014] |
| N+P | **-0.052±0.018** | **-2.880** | **0.004** | **[-0.088, -0.0167]** |
| *N*mass | N | 139 | **0.124±0.021** | **5.937** | **<0.001** | **[0.083, 0.165]** |
| P | -0.002±0.012 | -0.127 | 0.899 | [-0.025, 0.022] |
| N+P | **0.118±0.021** | **5.462** | **<0.001** | **[0.075, 0.160]** |
| *N*area | N | 84 | **0.125±0.042** | **2.987** | **0.003** | **[0.043, 0.208]** |
| P | 0.026±0.042 | 0.617 | 0.537 | [-0.056, 0.108] |
| N+P | **0.150±0.036** | **4.138** | **<0.001** | **[0.079, 0.221]** |
| *P*mass | N | 133 | **-0.075±0.032** | **-2.365** | **0.018** | **[-0.136, -0.013]** |
| P | **0.449±0.066** | **6.808** | **<0.001** | **[0.320, 0.578]** |
| N+P | **0.366±0.057** | **6.387** | **<0.001** | **[0.253, 0.478]** |
| *P*area | N | 79 | -0.054±0.075 | -0.720 | 0.472 | [-0.201, 0.093] |
| P | **0.530±0.113** | **4.693** | **<0.001** | **[0.309, 0.751]** |
| N+P | **0.383±0.110** | **3.489** | **<0.001** | **[0.168, 0.598]** |

\*Significant effects noted in bold font. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2).

**Table S3** Meta-analytic results summarizing the effects of N, P, and N+P on traits related to leaf photosynthesis

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient addition** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *A*sat | N | 85 | 0.095±0.073 | 1.313 | 0.189 | [-0.047, 0.238] |
| P | 0.083±0.083 | 1.006 | 0.315 | [-0.079, 0.245] |
| N+P | **0.214±0.096** | **2.227** | **0.026** | **[0.026, 0.402]** |
| *V*cmax | N | 42 | 0.007±0.093 | 0.078 | 0.938 | [-0.175, 0.190] |
| P | 0.115±0.072 | 1.607 | 0.108 | [-0.025, 0.256] |
| N+P | *0.164±0.085* | *1.937* | *0.053* | *[-0.002, 0.331]* |
| *J*max | N | 40 | 0.091±0.061 | 1.502 | 0.133 | [-0.028, 0.209] |
| P | **0.177±0.079** | **2.248** | **0.025** | **[0.023, 0.332]** |
| N+P | **0.261±0.027** | **9.601** | **<0.001** | **[0.208, 0.315]** |
| *J*max:*V*cmax | N | 32 | *0.003±0.002* | *1.695* | *0.090* | *[0.000, 0.007]* |
| P | 0.000±0.002 | -0.298 | 0.766 | [-0.004, 0.003] |
| N+P | **0.012±0.002** | **5.291** | **<0.001** | **[0.007, 0.016]** |
| *PNUE* | N | 58 | 0.057±0.118 | 0.483 | 0.629 | [-0.174, 0.287] |
| P | 0.151±0.132 | 1.142 | 0.253 | [-0.108, 0.409] |
| N+P | 0.124±0.189 | 0.656 | 0.512 | [-0.246, 0.494] |
| *PPUE* | N | 59 | 0.194±0.132 | 1.469 | 0.142 | [-0.065, 0.452] |
| P | -0.171±0.182 | 0.939 | 0.348 | [-0.528, 0.186] |
| N+P | -0.053±0.182 | -0.291 | 0.771 | [-0.411, 0.304] |

\*Significant effects noted in bold font. Key: *A*sat=light-saturated net photosynthesis rate (μmol m-2 s-1); *V*cmax=maximum rate of Rubisco carboxylation (μmol m-2 s-1); *J*max=maximum rate of electron transport for RuBP regeneration (μmol m-2 s-1); *J*max:*V*cmax=ratio of the maximum rate of electron transport for RuBP regeneration to the maximum rate of Rubisco carboxylation (unitless); *PNUE*=photosynthetic nitrogen use efficiency (μmol gN-1 s-1); *PPUE*=photosynthetic phosphorus use efficiency (μmol gP-1 s-1)

**Table S4** Meta-analytic results summarizing the effects of N, P, and N+P on whole-plant traits

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient addition** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *Total biomass* | N | 42 | 0.034±0.053 | 0.643 | 0.520 | [-0.070, 0.139] |
| P | **0.155±0.077** | **2.007** | **0.045** | **[0.004, 0.307]** |
| N+P | **0.379±0.078** | **4.871** | **<0.001** | **[0.226, 0.531]** |
| *Aboveground biomass* | N | 125 | **0.326±0.037** | **8.753** | **<0.001** | **[0.253, 0.399]** |
| P | **0.191±0.033** | **5.741** | **<0.001** | **[0.126, 0.257]** |
| N+P | **0.627±0.480** | **13.106** | **<0.001** | **[0.533, 0.721]** |
| *Belowground biomass* | N | 63 | -0.015±0.070 | -0.218 | 0.828 | [-0.151, 0.121] |
| P | 0.032±0.043 | 0.745 | 0.456 | [0.053, 0.117] |
| N+P | 0.101±0.074 | 1.358 | 0.174 | [-0.045, 0.245] |
| *Root mass fraction* | N | 37 | **-0.158±0.047** | **-3.400** | **<0.001** | **[-0.250, -0.067]** |
| P | *-0.070±0.038* | *-1.828* | *0.068* | *[-0.145, 0.005]* |
| N+P | **-0.148±0.046** | **-3.252** | **0.001** | **[-0.237, -0.059]** |
| *Root:shoot ratio* | N | 40 | **-0.341±0.090** | **-3.802** | **<0.001** | **[-0.516, -0.165]** |
| P | **-0.227±0.102** | **-2.226** | **0.026** | **[-0.426, -0.027]** |
| N+P | **-0.401±0.114** | **-3.517** | **<0.001** | **[-0.625, -0.178]** |

\*Significant effects noted in bold font.

**Table S5** Meta-analytic results summarizing the interaction effect on leaf nutrient, leaf photosynthetic, and whole-plant traits

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Trait** | **k** | **Coefficient (±SE)** | **Z-value** | ***p*-value** | **95% CI range** |
| *M*area | 88 | -0.038±0.083 | -0.459 | 0.646 | [-0.201, 0.125] |
| *N*mass | 139 | 0.026±0.062 | 0.423 | 0.672 | [-0.096, 0.149] |
| *N*area | 84 | -0.039±0.178 | -0.219 | 0.827 | [-0.388, 0.310] |
| *P*mass | 133 | -0.119±0.067 | -1.791 | 0.075 | [-0.249, 0.012] |
| *P*area | 79 | -0.084±0.171 | -0.489 | 0.625 | [-0.419, 0.252] |
| *A*sat | 85 | 0.176±0.248 | 0.709 | 0.479 | [-0.311, 0.663] |
| *V*cmax | 42 | 0.155±0.266 | 0.584 | 0.560 | [-0.366, 0.676] |
| *J*max | 40 | 0.143±0.294 | 0.486 | 0.627 | [-0.433, 0.719] |
| *J*max:*V*cmax | 32 | 0.088±0.115 | 0.761 | 0.447 | [-0.138, 0.313] |
| *PNUE* | 58 | 0.134±0.395 | 0.340 | 0.734 | [-0.639, 0.908] |
| *PPUE* | 59 | -0.116±0.278 | -0.417 | 0.677 | [-0.661, 0.429] |
| *Total biomass* | 42 | 0.134±0.104 | 1.289 | 0.197 | [-0.069, 0.337] |
| ***Aboveground biomass*** | **125** | **0.182±0.075** | **2.418** | **0.016** | **[0.035, 0.330]** |
| *Belowground biomass* | 63 | 0.039±0.090 | 0.429 | 0.668 | [-0.138, 0.216] |
| *Root mass fraction* | 40 | 0.122±0.129 | 0.940 | 0.347 | [-0.132, 0.375] |
| *Root:shoot* | 37 | 0.128±0.139 | 0.920 | 0.358 | [-0.145, 0.401] |

\*Significant effects noted in bold font. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2); *A*sat=light-saturated net photosynthesis rate (μmol m-2 s-1); *V*cmax=maximum rate of Rubisco carboxylation (μmol m-2 s-1); *J*max=maximum rate of electron transport for RuBP regeneration (μmol m-2 s-1); *J*max:*V*cmax=ratio of the maximum rate of electron transport for RuBP regeneration to the maximum rate of Rubisco carboxylation (unitless); *PNUE*=photosynthetic nitrogen use efficiency (μmol gN-1 s-1); *PPUE*=photosynthetic phosphorus use efficiency (μmol gP-1 s-1)

**Table S6** Climate moderator effects on leaf nutrient responses to nutrient addition\*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *T*g | 0.0014±0.0030 | 0.464 | 0.643 | [-0.004, 0.007] |
| *AI*g | 0.0374±0.0244 | 1.530 | 0.126 | [-0.011, 0.085] |
| *PAR*g | 0.0000±0.0002 | -0.258 | 0.796 | [0.000, 0.000] |
| p | *T*g | 0.0037±0.0025 | 1.450 | 0.147 | [-0.001, 0.009] |
| ***AI*g** | **0.0488±0.0209** | **2.328** | **0.020** | **[0.008, 0.090]** |
| *PAR*g | 0.0002±0.0001 | 1.476 | 0.140 | [0.000, 0.000] |
| np | *Tg* | *0.0059±0.0031* | *1.873* | *0.061* | *[0.000, 0.012]* |
| ***AI*g** | **0.0762±0.0268** | **2.840** | **0.005** | **[0.024, 0.129]** |
| *PAR*g | 0.0002±0.0002 | 1.211 | 0.226 | [0.000, 0.001] |
| *N*mass | n | ***T*g** | **-0.0067±0.0026** | **-2.536** | **0.011** | **[-0.012, -0.002]** |
| ***AI*g** | **-0.0562±0.0288** | **-1.951** | **0.050** | **[-0.113, 0.000]** |
| *PAR*g | -0.0001±0.0002 | -0.577 | 0.564 | [0.000, 0.000] |
| p | *T*g | 0.0016±0.0022 | 0.721 | 0.471 | [-0.003, 0.006] |
| *AI*g | -0.0206±0.0253 | -0.814 | 0.415 | [-0.070, 0.029] |
| *PAR*g | -0.0001±0.0001 | -0.449 | 0.653 | [0.000, 0.000] |
| np | ***Tg*** | **-0.0069±0.0030** | **-2.287** | **0.022** | **[-0.013, -0.001]** |
| *AI*g | -0.0399±0.0331 | -1.204 | 0.229 | [-0.105, 0.025] |
| *PAR*g | -0.0001±0.0002 | -0.740 | 0.459 | [-0.001, 0.000] |
| *N*area | n | *T*g | *-0.0129±0.0067* | *-1.914* | *0.056* | *[-0.026, 0.000]* |
| *AI*g | *-0.1183±0.0675* | *-1.753* | *0.080* | *[-0.251, 0.014]* |
| *PAR*g | 0.0000±0.0004 | 0.020 | 0.984 | [-0.001, 0.001] |
| p | *T*g | 0.0010±0.0052 | 0.193 | 0.847 | [-0.009, 0.011] |
| *AI*g | 0.0274±0.0453 | 0.605 | 0.545 | [-0.061, 0.116] |
| *PAR*g | 0.0001±0.0003 | 0.408 | 0.684 | [0.000, 0.001] |
| np | *Tg* | -0.0036±0.0048 | -0.746 | 0.455 | [-0.013, 0.006] |
| *AI*g | -0.0221±0.0406 | -0.543 | 0.587 | [-0.102, 0.057] |
| *PAR*g | 0.0002±0.0003 | 0.591 | 0.554 | [0.000, 0.001] |
| *P*mass | n | *T*g | 0.0046±0.0050 | 0.916 | 0.360 | [-0.005, 0.014] |
| *AI*g | 0.0374±0.0527 | 0.710 | 0.478 | [-0.066, 0.141] |
| *PAR*g | -0.0005±0.0003 | -1.616 | 0.106 | [-0.001, 0.000] |
| p | *T*g | **-0.0215±0.0105** | **-2.053** | **0.040** | **[-0.042, -0.001]** |
| *AI*g | *-0.1794±0.1044* | *-1.717* | *0.086* | *[-0.384, 0.025]* |
| *PAR*g | 0.0010±0.0006 | 1.629 | 0.103 | [0.000, 0.002] |
| np | *Tg* | -0.0195±0.4826 | -0.040 | 0.968 | [-0.965, 0.926] |
| *AI*g | **-0.0231±0.0094** | **-2.454** | **0.014** | **[-0.042, -0.005]** |
| *PAR*g | -0.0879±0.0931 | -0.944 | 0.345 | [-0.270, 0.095] |

**Table S6 (cont.)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *P*area | n | *T*g | 0.0080±0.0089 | 0.896 | 0.370 | [-0.010, 0.026] |
| *AI*g | -0.0582±0.0768 | -0.758 | 0.448 | [-0.209, 0.092] |
| *PAR*g | -0.0008±0.0005 | -1.595 | 0.111 | [-0.002, 0.000] |
| p | *T*g | *-0.0299±0.0163* | *-1.829* | *0.067* | *[-0.062, 0.002]* |
| *AI*g | -0.1855±0.1290 | -1.438 | 0.150 | [-0.438, 0.067] |
| *PAR*g | 0.0013±0.0009 | 1.503 | 0.133 | [0.000, 0.003] |
| np | *Tg* | -0.0178±0.0187 | -0.950 | 0.342 | [-0.054, 0.019] |
| *AI*g | -0.1663±0.1495 | -1.112 | 0.266 | [-0.459, 0.127] |
| *PAR*g | **0.0020±0.0010** | **1.991** | **0.046** | **[0.000, 0.004]** |

\*Trait acronyms are as defined in Fig. 2. Rows where *p*-values are less than 0.05 are noted in bold font and *p*-values where 0.5<*p*<0.1 are noted in italic font. Key: *T*g=mean growing season temperature (°C), *AI*g=mean growing season aridity index (unitless), *PAR*g=mean growing season photosynthetically active radiation (μmol m-2 s-1)

**Table S7** Climate moderator effects on whole-plant responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *Total biomass* | n | *Tg* | *-0.0267±0.0138* | *-1.927* | *0.054* | *[-0.054, 0.000]* |
| *AI*g | 0.0118±0.0924 | 0.128 | 0.899 | [-0.169, 0.193] |
| *PAR*g | 0.0005±0.0005 | 0.989 | 0.323 | [0.000, 0.001] |
| p | *Tg* | *-0.0218±0.0126* | *-1.730* | *0.084* | *[-0.046, 0.003]* |
| *AI*g | -0.0497±0.0819 | -0.607 | 0.544 | [-0.210, 0.111] |
| *PAR*g | 0.0004±0.0005 | 0.744 | 0.457 | [-0.001, 0.001] |
| np | *Tg* | *-0.0283±0.0156* | *-1.813* | *0.070* | *[-0.059, 0.002]* |
| *AI*g | -0.1616±0.1220 | -1.325 | 0.185 | [-0.401, 0.077] |
| *PAR*g | 0.0000±0.0006 | -0.072 | 0.943 | [-0.001, 0.001] |
| *Aboveground biomass* | n | *T*g | -0.0036±0.0065 | -0.560 | 0.576 | [-0.016, 0.009] |
| *AI*g | 0.0819±0.0701 | 1.168 | 0.243 | [-0.056, 0.219] |
| *PAR*g | 0.0002±0.0003 | 0.569 | 0.569 | [0.000, 0.001] |
| p | *T*g | -0.0013±0.0071 | -0.189 | 0.850 | [-0.015, 0.013] |
| *AIg* | *0.1392±0.0748* | *1.860* | *0.063* | *[-0.007, 0.286]* |
| *PAR*g | 0.0004±0.0003 | 1.330 | 0.184 | [0.000, 0.001] |
| np | *Tg* | -0.0126±0.0097 | -1.299 | 0.194 | [-0.032, 0.006] |
| *AI*g | -0.0795±0.1058 | -0.751 | 0.453 | [-0.287, 0.128] |
| *PAR*g | -0.0003±0.0004 | -0.697 | 0.486 | [-0.001, 0.001] |
| *Belowground biomass* | n | *T*g | -0.0030±0.0090 | -0.328 | 0.743 | [-0.021, 0.015] |
| *AI*g | 0.1623±0.1021 | 1.590 | 0.112 | [-0.038, 0.362] |
| *PAR*g | 0.0007±0.0005 | 1.443 | 0.149 | [0.000, 0.002] |
| p | *T*g | 0.0005±0.0077 | 0.069 | 0.945 | [-0.015, 0.016] |
| *AI*g | -0.0293±0.0846 | -0.346 | 0.729 | [-0.195, 0.136] |
| *PAR*g | 0.0003±0.0004 | 0.610 | 0.542 | [-0.001, 0.001] |
| np | *Tg* | -0.0092±0.0101 | -0.912 | 0.362 | [-0.029, 0.011] |
| *AI*g | 0.1430±0.1150 | 1.244 | 0.214 | [-0.082, 0.368] |
| ***PAR*g** | **0.0012±0.0006** | **2.202** | **0.028** | **[0.000, 0.002]** |
| *Root mass fraction* | n | *T*g | -0.0064±0.0136 | -0.469 | 0.639 | [-0.033, 0.020] |
| *AI*g | 0.1145±0.1062 | 1.078 | 0.281 | [-0.094, 0.323] |
| *PARg* | *0.0012±0.0006* | *1.889* | *0.059* | *[0.000, 0.002]* |
| p | *T*g | -0.0097±0.0104 | -0.930 | 0.353 | [-0.030, 0.011] |
| *AI*g | -0.0835±0.0835 | -1.000 | 0.317 | [-0.247, 0.080] |
| *PAR*g | 0.0003±0.0005 | 0.540 | 0.589 | [-0.001, 0.001] |
| np | *Tg* | 0.0012±0.0138 | 0.089 | 0.929 | [-0.026, 0.028] |
| *AI*g | 0.1242±0.1083 | 1.146 | 0.252 | [-0.088, 0.336] |
| *PAR*g | 0.0008±0.0006 | 1.328 | 0.184 | [0.000, 0.002] |

**Table S7 (cont.)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef. (±SE)** | **Z-value** | ***p*-value** | **95% CI** |
| *Root:shoot* | n | *T*g | -0.0103±0.0278 | -0.371 | 0.711 | [-0.065, 0.044] |
| *AI*g | 0.0359±0.2472 | 0.145 | 0.885 | [-0.449, 0.520] |
| *PAR*g | 0.0011±0.0013 | 0.841 | 0.401 | [-0.001, 0.004] |
| p | *T*g | -0.0405±0.0285 | -1.422 | 0.155 | [-0.096, 0.015] |
| ***AI*g** | **-0.5298±0.2457** | **-2.156** | **0.031** | **[-1.011, -0.048]** |
| *PAR*g | -0.0008±0.0014 | -0.602 | 0.547 | [-0.004, 0.002] |
| np | *Tg* | -0.0042±0.0362 | -0.116 | 0.908 | [-0.075, 0.067] |
| *AI*g | -0.0062±0.3200 | -0.019 | 0.985 | [-0.633, 0.621] |
| *PAR*g | 0.0004±0.0017 | 0.227 | 0.821 | [-0.003, 0.004] |

\*Trait acronyms are as defined in Fig. 2. Rows where *p*-values are less than 0.05 are noted in bold font and *p*-values where 0.5<*p*<0.1 are noted in italic font. Key: *T*g=mean growing season temperature (°C), *AI*g=mean growing season aridity index (unitless), *PAR*g=mean growing season photosynthetically active radiation (μmol m-2 s-1)

**Table S8** N2-fixer moderator effects on leaf nutrient responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *non-fixer* | **-0.044** | **3.508** | **<0.001** | **[-0.082, -0.007]** |
| *N2-fixer* | **0.126** | **[0.027, 0.224]** |
| p | *non-fixer* | **-0.007** | **-4.584** | **<0.001** | **[-0.043, 0.028]** |
| *N2-fixer* | **-0.171** | **[-0.247, -0.095]** |
| np | *non-fixer* | **-0.051** | **3.015** | **0.003** | **[-0.084, -0.019]** |
| *N2-fixer* | **0.074** | **[-0.010, 0.158]** |
| *N*mass | n | *non-fixer* | **0.153** | **-4.498** | **<0.001** | **[0.106, 0.199]** |
| *N2-fixer* | **-0.031** | **[-0.119, 0.056]** |
| p | *non-fixer* | **-0.006** | **3.454** | **0.001** | **[-0.032, 0.020]** |
| *N2-fixer* | **0.115** | **[0.048, 0.181]** |
| np | *non-fixer* | **0.137** | **-2.258** | **0.024** | **[0.089, 0.185]** |
| *N2-fixer* | **0.025** | **[-0.076, 0.127]** |
| *N*area | n | *non-fixer* | 0.124 | 0.625 | 0.532 | [0.041, 0.207] |
| *N2-fixer* | 0.159 | [0.026, 0.292] |
| p | *non-fixer* | 0.021 | 1.236 | 0.217 | [-0.062, 0.104] |
| *N2-fixer* | 0.094 | [-0.042, 0.231] |
| np | *non-fixer* | 0.150 | -0.116 | 0.908 | [0.079, 0.221] |
| *N2-fixer* | 0.143 | [0.010, 0.276] |
| *P*mass | n | *non-fixer* | **-0.094** | **2.595** | **0.009** | **[-0.162, -0.026]** |
| *N2-fixer* | **0.041** | **[-0.074, 0.157]** |
| p | *non-fixer* | **0.444** | **5.376** | **<0.001** | **[0.298, 0.589]** |
| *N2-fixer* | **0.698** | **[0.531, 0.865]** |
| np | *non-fixer* | **0.359** | **2.021** | **0.043** | **[0.231, 0.486]** |
| *N2-fixer* | **0.514** | **[0.324, 0.704]** |
| *P*area | n | *non-fixer* | **-0.073** | **7.261** | **<0.001** | **[-0.226, 0.080]** |
| *N2-fixer* | **0.335** | **[0.150, 0.521]** |
| p | *non-fixer* | **0.512** | **4.506** | **<0.001** | **[0.289, 0.735]** |
| *N2-fixer* | **0.776** | **[0.529, 1.023]** |
| np | *non-fixer* | **0.376** | **3.292** | **0.001** | **[0.161, 0.592]** |
| *N2-fixer* | **0.628** | **[0.368, 0.889]** |

\*Significant effects noted in bold font. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2)

**Table S9** Mycorrhizal acquisition strategy moderator effects on leaf nutrient responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *mining* | **0.011** | **-2.472** | **0.013** | **[-0.040, 0.061]** |
| *scavenging* | **-0.046** | **[-0.080, -0.011]** |
| p | *mining* | 0.003 | -1.026 | 0.305 | [-0.042, 0.049] |
| *scavenging* | -0.018 | [-0.050, 0.014] |
| np | *mining* | **-0.161** | **4.265** | **<0.001** | **[-0.227, -0.094]** |
| *scavenging* | **-0.030** | **[-0.072, 0.012]** |
| *N*mass | n | *mining* | 0.149 | -0.561 | 0.575 | [0.088, 0.211] |
| *scavenging* | 0.137 | [0.091, 0.183] |
| p | *mining* | -0.017 | 1.077 | 0.281 | [-0.065, 0.032] |
| *scavenging* | 0.008 | [-0.017, 0.033] |
| np | *mining* | 0.158 | -1.041 | 0.298 | [0.086, 0.230] |
| *scavenging* | 0.126 | [0.080, 0.173] |
| *N*area | n | *mining* | **0.042** | **2.236** | **0.025** | **[-0.069, 0.153]** |
| *scavenging* | **0.133** | **[0.050, 0.217]** |
| p | *mining* | 0.040 | -0.402 | 0.688 | [-0.066, 0.146] |
| *scavenging* | 0.024 | [-0.057, 0.105] |
| np | *mining* | 0.155 | -0.150 | 0.881 | [0.055, 0.256] |
| *scavenging* | 0.149 | [0.077, 0.221] |
| *P*mass | n | *mining* | **-0.227** | **6.069** | **<0.001** | **[-0.305, -0.149]** |
| *scavenging* | **-0.066** | **[-0.129, -0.003]** |
| p | *mining* | **0.805** | **-6.408** | **<0.001** | **[0.637, 0.972]** |
| *scavenging* | **0.435** | **[0.303, 0.567]** |
| np | *mining* | **0.261** | **3.544** | **<0.001** | **[0.119, 0.403]** |
| *scavenging* | **0.381** | **[0.252, 0.510]** |
| *P*area | n | *mining* | -0.048 | -0.087 | 0.931 | [-0.242, 0.145] |
| *scavenging* | -0.055 | [-0.202, 0.093] |
| p | *mining* | **1.071** | **-8.600** | **<0.001** | **[0.796, 1.346]** |
| *scavenging* | **0.459** | **[0.213, 0.706]** |
| np | *mining* | 0.401 | -0.284 | 0.777 | [0.153, 0.649] |
| *scavenging* | 0.380 | [0.165, 0.595] |

\*Significant effects noted in bold font. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2)

**Table S10** Photosynthetic pathway moderator effects on leaf nutrient responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *M*area | n | *C3* | **-0.009** | **-3.662** | **<0.001** | **[-0.043, 0.025]** |
| *C4* | **-0.126** | **[-0.183, -0.069]** |
| p | *C3* | -0.023 | 1.628 | 0.104 | [-0.055, 0.010] |
| *C4* | 0.019 | [-0.031, 0.069] |
| np | *C3* | **-0.019** | **-4.699** | **<0.001** | **[-0.061, 0.022]** |
| *C4* | **-0.172** | **[-0.237, -0.106]** |
| *N*mass | n | *C3* | **0.118** | **2.643** | **0.008** | **[0.071, 0.166]** |
| *C4* | **0.243** | **[0.153, 0.334]** |
| p | *C3* | 0.000 | 1.645 | 0.100 | [-0.024, 0.024] |
| *C4* | 0.054 | [-0.008, 0.115] |
| np | *C3* | **0.108** | **3.123** | **0.002** | **[0.059, 0.157]** |
| *C4* | **0.247** | **[0.159, 0.335]** |
| *N*area | n | *C3* | **0.156** | **-2.661** | **0.008** | **[0.066, 0.247]** |
| *C4* | **0.021** | **[-0.096, 0.138]** |
| p | *C3* | 0.029 | -0.285 | 0.776 | [-0.056, 0.114] |
| *C4* | 0.015 | [-0.095, 0.125] |
| np | *C3* | **0.189** | **-5.865** | **<0.001** | **[0.098, 0.280]** |
| *C4* | **-0.053** | **[-0.165, 0.058]** |
| *P*mass | n | *C3* | -0.095 | 1.260 | 0.208 | [-0.170, -0.021] |
| *C4* | 0.016 | [-0.155, 0.187] |
| p | *C3* | **0.511** | **-2.884** | **0.004** | **[0.355, 0.667]** |
| *C4* | **0.178** | **[-0.075, 0.430]** |
| np | *C3* | 0.367 | 0.124 | 0.901 | [0.239, 0.495] |
| *C4* | 0.381 | [0.147, 0.615] |
| *P*area | n | *C3* | -0.069 | 1.032 | 0.302 | [-0.220, 0.082] |
| *C4* | 0.038 | [-0.191, 0.267] |
| p | *C3* | 0.559 | -1.584 | 0.113 | [0.323, 0.794] |
| *C4* | 0.373 | [0.068, 0.677] |
| np | *C3* | 0.411 | -1.590 | 0.112 | [0.182, 0.641] |
| *C4* | 0.225 | [-0.075, 0.524] |

\*Significant effects noted in bold font. Key: *M*area=leaf biomass per unit leaf area (g m-2); *N*mass=leaf nitrogen content per unit leaf biomass (gN g-1); *N*area=leaf nitrogen content per unit leaf area (gN m-2); *P*mass=leaf phosphorus content per unit leaf biomass (gP g-1); *P*area=leaf phosphorus content per unit leaf area (gP m-2)

**Table S11** N2-fixer moderator effects on leaf photosynthetic responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *A*sat | n | *non-fixer* | **0.084** | **-2.900** | **0.004** | **[-0.060, 0.229]** |
| *N2-fixer* | **-0.281** | **[-0.563, 0.001]** |
| p | *non-fixer* | 0.079 | 0.083 | 0.934 | [-0.095, 0.252] |
| *N2-fixer* | 0.088 | [-0.179, 0.354] |
| np | *non-fixer* | **0.221** | **-4.135** | **<0.001** | **[0.023, 0.420]** |
| *N2-fixer* | **-0.275** | **[-0.58, 0.031]** |
| *V*cmax | n | *non-fixer* | **0.069** | **-3.879** | **<0.001** | **[-0.047, 0.184]** |
| *N2-fixer* | **-0.291** | **[-0.478, -0.105]** |
| p | *non-fixer* | **0.143** | **-2.309** | **0.021** | **[0.013, 0.274]** |
| *N2-fixer* | **-0.057** | **[-0.250, 0.135]** |
| np | *non-fixer* | **0.251** | **-4.918** | **<0.001** | **[0.137, 0.366]** |
| *N2-fixer* | **-0.194** | **[-0.378, -0.010]** |
| *J*max | n | *non-fixer* | **0.123** | **-2.001** | **0.045** | **[0.028, 0.219]** |
| *N2-fixer* | **-0.039** | **[-0.191, 0.114]** |
| p | *non-fixer* | 0.175 | 0.218 | 0.828 | [0.017, 0.333] |
| *N2-fixer* | 0.195 | [-0.027, 0.417] |
| np | *non-fixer* | **0.294** | **-4.209** | **<0.001** | **[0.244, 0.344]** |
| *N2-fixer* | **-0.095** | **[-0.270, 0.079]** |
| *PNUE* | n | *non-fixer* | 0.056 | 0.740 | 0.459 | [-0.175, 0.287] |
| *N2-fixer* | 0.166 | [-0.204, 0.536] |
| p | *non-fixer* | 0.150 | 1.037 | 0.300 | [-0.109, 0.408] |
| *N2-fixer* | 0.284 | [-0.077, 0.646] |
| np | *non-fixer* | 0.124 | -0.113 | 0.910 | [-0.246, 0.494] |
| *N2-fixer* | 0.108 | [-0.347, 0.564] |
| *PPUE* | n | *non-fixer* | **0.206** | **-5.627** | **<0.001** | **[-0.064, 0.475]** |
| *N2-fixer* | **-0.491** | **[-0.852, -0.131]** |
| p | *non-fixer* | -0.169 | -1.038 | 0.299 | [-0.523, 0.185] |
| *N2-fixer* | -0.318 | [-0.766, 0.131] |
| np | *non-fixer* | **-0.044** | **-4.961** | **<0.001** | **[-0.397, 0.309]** |
| *N2-fixer* | **-0.808** | **[-1.270, -0.346]** |

**Table S12** Mycorrhizal acquisition strategy moderator effects on leaf nutrient responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *A*sat | n | *mining* | **-0.142** | **4.899** | **<0.001** | **[-0.336, 0.052]** |
| *scavenging* | **0.138** | **[-0.037, 0.313]** |
| p | *mining* | 0.091 | -0.264 | 0.792 | [-0.101, 0.283] |
| *scavenging* | 0.076 | [-0.098, 0.250] |
| np | *mining* | **0.056** | **3.583** | **<0.001** | **[-0.170, 0.283]** |
| *scavenging* | **0.256** | **[0.045, 0.466]** |
| *V*cmax | n | *mining* | **-0.199** | **5.064** | **<0.001** | **[-0.433, 0.036]** |
| *scavenging* | **0.090** | **[-0.132, 0.313]** |
| p | *mining* | 0.120 | -0.108 | 0.914 | [-0.043, 0.283] |
| *scavenging* | 0.114 | [-0.031, 0.259] |
| np | *mining* | **0.026** | **3.199** | **0.001** | **[-0.198, 0.251]** |
| *scavenging* | **0.207** | **[-0.003, 0.417]** |
| *J*max | n | *mining* | **-0.056** | **4.278** | **<0.001** | **[-0.222, 0.110]** |
| *scavenging* | **0.179** | **[0.024, 0.334]** |
| p | *mining* | 0.185 | -0.171 | 0.864 | [0.008, 0.361] |
| *scavenging* | 0.175 | [0.015, 0.336] |
| np | *mining* | **0.096** | **3.302** | **0.001** | **[-0.072, 0.264]** |
| *scavenging* | **0.283** | **[0.129, 0.436]** |
| *PNUE* | n | *mining* | **-0.123** | **3.706** | **<0.001** | **[-0.382, 0.136]** |
| *scavenging* | **0.095** | **[-0.146, 0.337]** |
| p | *mining* | 0.147 | 0.087 | 0.931 | [-0.126, 0.420] |
| *scavenging* | 0.151 | [-0.109, 0.412] |
| np | *mining* | 0.157 | -0.681 | 0.496 | [-0.226, 0.540] |
| *scavenging* | 0.118 | [-0.253, 0.489] |
| *PPUE* | n | *mining* | **-0.018** | **3.001** | **0.003** | **[-0.335, 0.298]** |
| *scavenging* | **0.223** | **[-0.062, 0.508]** |
| p | *mining* | **-0.583** | **5.158** | **<0.001** | **[-1.012, -0.154]** |
| *scavenging* | **-0.094** | **[-0.494, 0.306]** |
| np | *mining* | **-0.229** | **2.184** | **0.029** | **[-0.629, 0.171]** |
| *scavenging* | **-0.026** | **[-0.394, 0.342]** |

**Table S13** Photosynthetic pathway moderator effects on leaf photosynthetic responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *A*sat | n | *C3* | 0.072 | 0.949 | 0.343 | [-0.074, 0.217] |
| *C4* | 0.185 | [-0.080, 0.450] |
| p | *C3* | *0.089* | *-1.646* | *0.100* | *[-0.085, 0.263]* |
| *C4* | *-0.067* | *[-0.312, 0.179]* |
| np | *C3* | 0.214 | 0.153 | 0.879 | [0.015, 0.413] |
| *C4* | 0.224 | [-0.007, 0.455] |
| *V*cmax | n | *C3* | 0.007 | 0.464 | 0.643 | [-0.176, 0.189] |
| *C4* | 0.082 | [-0.283, 0.447] |
| p | *C3* | 0.117 | -1.365 | 0.172 | [-0.021, 0.256] |
| *C4* | -0.023 | [-0.264, 0.218] |
| np | *C3* | 0.165 | -0.058 | 0.954 | [-0.002, 0.331] |
| *C4* | 0.160 | [-0.060, 0.380] |
| *J*max | n | *C3* | 0.091 | 0.145 | 0.885 | [-0.028, 0.209] |
| *C4* | 0.117 | [-0.255, 0.488] |
| p | *C3* | 0.179 | -1.509 | 0.131 | [0.027, 0.331] |
| *C4* | 0.014 | [-0.245, 0.274] |
| np | *C3* | 0.256 | -0.220 | 0.826 | [0.190, 0.322] |
| *C4* | 0.237 | [0.065, 0.409] |
| *PNUE* | n | *C3* | 0.056 | 0.831 | 0.406 | [-0.175, 0.287] |
| *C4* | 0.168 | [-0.181, 0.517] |
| p | *C3* | *0.152* | *-1.897* | *0.058* | *[-0.106, 0.410]* |
| *C4* | *-0.044* | *[-0.370, 0.283]* |
| np | *C3* | *0.121* | *1.834* | *0.067* | *[-0.251, 0.492]* |
| *C4* | *0.257* | *[-0.141, 0.655]* |
| *PPUE* | n | *C3* | 0.196 | -0.912 | 0.362 | [-0.065, 0.457] |
| *C4* | 0.102 | [-0.224, 0.428] |
| p | *C3* | -0.172 | 0.507 | 0.612 | [-0.531, 0.187] |
| *C4* | -0.097 | [-0.555, 0.362] |
| np | *C3* | **-0.057** | **2.638** | **0.008** | **[-0.417, 0.303]** |
| *C4* | **0.384** | **[-0.101, 0.869]** |

**Table S14** Photosynthetic pathway moderator effects on leaf photosynthetic responses to nutrient addition

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trait** | **Nutrient** | **Moderator** | **Coef.** | **Z-value** | ***p*-value** | **95% CI** |
| *Total biomass* | n | *C3* | 0.209 | -0.970 | 0.332 | [-0.532, 0.951] |
| *C4* | -0.402 | [-1.389, 0.586] |
| p | *C3* | **0.012** | **8.491** | **<0.001** | **[-0.299, 0.323]** |
| *C4* | **1.687** | **[1.457, 1.917]** |
| np | *C3* | 0.576 | 1.639 | 0.101 | [-0.206, 1.358] |
| *C4* | 1.621 | [0.647, 2.595] |
| *Aboveground biomass* | n | *C3* | 0.472 | -0.328 | 0.743 | [0.155, 0.788] |
| *C4* | 0.338 | [-0.398, 1.074] |
| p | *C3* | 0.177 | -0.051 | 0.960 | [-0.094, 0.448] |
| *C4* | 0.160 | [-0.470, 0.789] |
| np | *C3* | 0.658 | -0.079 | 0.937 | [0.237, 1.079] |
| *C4* | 0.616 | [-0.338, 1.571] |
| *Belowground biomass* | n | *C3* | 0.167 | 0.267 | 0.790 | [-0.356, 0.691] |
| *C4* | 0.296 | [-0.489, 1.081] |
| p | *C3* | -0.115 | 2.096 | 0.960 | [-0.314, 0.084] |
| *C4* | 0.252 | [-0.027, 0.531] |
| np | *C3* | 0.036 | 0.661 | 0.509 | [-0.589, 0.661] |
| *C4* | 0.421 | [-0.533, 1.375] |

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