Oikos

OIK-01485

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		Characteristics			Biomass		Herbivory		
Species	Status	No. of grid cells	Habitats	Year of establishment	No nutrient	Nutrient	Leaves damaged	Difference in leaves damaged	Invertebrates
Eryngium giganteum	alien non-invasive	4	2	Unknown	6	6	8	8	8
Heracleum mantegazzianum	alien invasive	420	2,7	1890	8	8	8	8	8
Oenanthe lachenalii	native	8	1,6		6	5	8	8	8
Artemisia borealis	native	6	3,7		3	4	8	8	8
Artemisia vulgaris	native	253	2,7		8	8	_	_	_
Aster lanceolatus	alien non-invasive	17	2,7	1850	8	7	7	7	8
Cirsium montanum	native	1	5,7,8,9		6	4	4	4	7
Conyza canadensis	alien invasive	140	2	1646-	7	7	8	8	8
Gnaphalium luteo-album	native	29	1,2		7	7	_	_	_
Inula helvetica	native	40	2,5,7,9		6	6	_	_	_
Rudbeckia hirta	alien non-invasive	27	2,7	1860	5	5	5	5	8
Senecio inaequidens	alien invasive	121	2,3	1889	8	7	8	8	8
Solidago canadensis	alien invasive	491	1,2	1736	8	8	7	7	8
Solidago virgaurea	native	207	7,9		_	_	8	8	8
Bidens bipinnata	alien non-invasive	4	2,3,7	1754 ‡	8	8	7	7	8
Bidens frondosa	alien invasive	45	1,2,9	1736	8	8	7	7	8
Bidens radiata	native	3	1,2		3	3	3	3	5
Bidens tripartita	native	57	1,2		7	6	6	6	8
Brachypodium sylvaticum	native	494	7,9		7	8	_	_	8
Eleusine indica	alien non-invasive	21	2	1900	8	8	_	_	8
Panicum capillare	alien invasive	136	2	1867	8	8	_	_	8
Persicaria orientalis	alien non-invasive	4	2,7	Unknown	4	4	4	4	4
Rumex maritimus	native	1	2		8	8	8	8	8
Rumex obtusifolius	native	602	2,6		8	8	8	8	8
Mimulus guttatus	alien non-invasive	23	1,2,4	1824	8	8	8	8	8
Scrophularia nodosa	native	358	2,9		8	7	8	8	8
Veronica anagallis-aquatica	native	131	1,2,4		8	8	8	8	8
Veronica peregrina	alien non-invasive	57	2	1760	8	7	8	8	8
Veronica persica	alien invasive	458	2	1805	7	7	8	8	8

Table A1. The 29 species used in this study, their status, the number of 5 × 5km grid cells in Switzerland occupied, and first date alien species were recorded as naturalised in central Europe (Klotz et al. 2002). Numbers in parentheses for Asteraceae species are sub-subplot groupings for this family. ‡From Hegi (1954). Habitat codes follow Landolt et al (2010): 1- Water bodies, banks and ditches; 2- Eutrophic terrestrial vegetation; 3- Outcrops, screes, sandy/gravel habitats; 4- Water sources and streams; 5- Mires; 6- Grasslands and meadows; 7-Dwarf shrub and tall herb communities; 8- Shrubland.

Table A2. Mean (and standard error) abundance of aphids and proportion of leaves damaged per plant per species, treated either without or with pesticide in the experiment. *- Species treated as 'Scrophulariaceae' taxonomic group; however *Mimulus guttatus* is in the Phrymaceae, and *Veronica* spp. are in the Plantaginaceae.

Species	Family	Status	Aphid abundance without pesticide	Aphid abundance with pesticide	Proportion of leaves damaged without pesticide	Proportion of leaves damaged with pesticide
Eryngium giganteum	Apiaceae	alien non-invasive	17.50 (7.64)	1.88 (0.95)	0.155 (0.055)	0.102 (0.080)
Heracleum mantegazzianum	Apiaceae	alien invasive	116.38 (15.10)	41.63 (13.13)	0.213 (0.055)	0.106 (0.088)
Oenanthe lachenalii	Apiaceae	native	42.75 (15.85)	6.50 (2.11)	0.344 (0.066)	0.147 (0.119)
Artemisia borealis	Asteraceae	native	14.00 (5.73)	1.88 (0.95)	0.180 (0.040)	0.065 (0.059)
Aster lanceolatus	Asteraceae	alien non-invasive	31.43 (8.75)	9.29 (3.00)	0.280 (0.051)	0.125 (0.061)
Cirsum montanum	Asteraceae	native	73.25 (28.30)	7.75 (3.52)	0.544 (0.096)	0.302 (0.096)
Conyza canadensis	Asteraceae	alien invasive	43.13 (15.17)	4.50 (1.27)	0.062 (0.013)	0.027 (0.023)
Rudbeckia hirta	Asteraceae	alien non-invasive	36.40 (16.77)	6.40 (5.42)	0.212 (0.031)	0.118 (0.059)
Senecio inaequidens	Asteraceae	alien invasive	11.88 (5.34)	3.13 (1.32)	0.063 (0.028)	0.034 (0.035)
Solidago canadensis	Asteraceae	alien invasive	26.57 (8.78)	1.57 (0.87)	0.057 (0.011)	0.017 (0.015)
Solidago virgaurea	Asteraceae	native	1.88 (1.60)	0.38 (0.18)	0.418 (0.033)	0.081 (0.112)
Bidens bipinnata	Asteraceae (Bidens)	alien non-invasive	61.71 (14.71)	18.43 (3.82)	0.053 (0.012)	0.012 (0.029)
Bidens frondosa	Asteraceae (Bidens)	alien invasive	1.29 (0.29)	1.71 (0.29)	0.024 (0.048)	0.070 (0.024)
Bidens radiata	Asteraceae (Bidens)	native	178.00 (57.46)	60.33 (16.05)	0.178 (0.058)	0.106 (0.178)
Bidens tripartita	Asteraceae (Bidens)	native	2.33 (0.21)	2.00 (0.37)	0.015 (0.032)	0.046 (0.015)
Brachypodium sylvaticum	Poaceae	native	1.63 (0.84)	0.38 (0.26)	0.000 (0.000)	0.000 (0.000)
Eleusine indica	Poaceae	alien non-invasive	6.50 (0.82)	0.75 (0.41)	0.000 (0.000)	0.000 (0.000)
Panicum capillare	Poaceae	alien invasive	4.00 (0.80)	1.25 (0.41)	0.000 (0.000)	0.000 (0.000)
Persicaria orientalis	Polygonaceae	alien non-invasive	80.75 (31.47)	33.50 (12.98)	0.346 (0.08)	0.159 (0.028)
Rumex maritimus	Polygonaceae	native	228.50 (82.89)	66.75 (19.49)	0.202 (0.059)	0.235 (0.050)
Rumex obtusifolius	Polygonaceae	native	216.88 (30.90)	67.75 (10.12)	0.257 (0.063)	0.153 (0.087)
Mimulus guttatus	Phrymaceae*	alien non-invasive	75.00 (12.89)	20.75 (8.42)	0.189 (0.036)	0.124 (0.059)
Scrophularia nodosa	Scrophulariaceae*	native	51.13 (12.53)	14.75 (3.26)	0.108 (0.050)	0.063 (0.037)
Veronica anagallis-aquatica	Plantaginaceae*	native	91.50 (19.77)	7.63 (1.08)	0.249 (0.089)	0.184 (0.045)
Veronica peregrina	Plantaginaceae*	alien non-invasive	85.38 (10.40)	14.25 (3.80)	0.063 (0.008)	0.011 (0.022)
Veronica persica	Plantaginaceae*	alien invasive	182.50 (64.06)	38.50 (19.18)	0.193 (0.060)	0.141 (0.068)

Table A3. Parameter estimates (and standard errors in parentheses) for linear mixed models of aboveground biomass (square root transformed) in relation to proportion of leaves damaged, for the herbivory set of plants that were either a) not treated with pesticide, or b) had pesticide treatment. Significant estimates ($p < 0.05$) are shown. Values for random effects represent standard deviations.

	Variable	(a) without pesticide	(b) with pesticide
Fixed effects	intercept	2.760 (0.449)	2.930 (0.499)
	proportion of leaves damaged	-0.892 (0.294)	0.450 (0.998)
Random intercepts	family	0.868	0.966
	species	1.000	1.126
Random slopes	family	0.209	1.906
	species	0.825	1.319
	residual	0.291	0.365

Table A4. Modelled intercept and slope estimates per species (as random effects), from linear mixed models assessing the relationship between aboveground biomass and proportion of leaves damaged for plants without and with pesticide treatment. Note that the intercepts and slopes were calculated from taxonomic group and species-level random effects.

		Without pesticide		With pesticide	
Family	Species	Intercept	Slope	Intercept	Slope
Apiaceae	*Eryngium giganteum*	0.609	-0.143	0.898	-0.801
Apiaceae	*Heracleum mantegazzianum*	1.660	-0.451	3.071	-3.572
Apiaceae	*Oenanthe lachenalii*	2.690	-2.588	4.377	2.588
Asteraceae	*Artemisia borealis*	1.660	-1.439	6.339	4.143
Asteraceae	*Aster lanceolatus*	3.266	-1.504	3.218	1.931
Asteraceae	*Cirsum montanum*	3.643	-0.540	1.932	-0.021
Asteraceae	*Conyza canadensis*	3.758	-0.825	3.371	-0.046
Asteraceae	*Rudbeckia hirta*	3.076	0.087	2.522	-1.517
Asteraceae	*Senecio inaequidens*	4.585	-1.236	5.815	2.459
Asteraceae	*Solidago Canadensis*	3.658	-0.550	1.820	-1.753
Asteraceae	*Solidago virgaurea*	2.691	-0.083	3.551	1.584
Asteraceae (Bidens)	*Bidens bipinnata*	2.732	-1.341	3.485	2.509
Asteraceae (Bidens)	*Bidens frondosa*	4.033	-1.713	1.811	-0.992
Asteraceae (Bidens)	*Bidens radiate*	1.440	-0.858	2.156	-2.140
Asteraceae (Bidens)	*Bidens tripartite*	1.881	-1.010	0.692	-0.657
Polygonaceae	*Persicaria orientalis*	4.990	-0.992	1.727	1.699
Polygonaceae	*Rumex maritimus*	3.360	-0.528	2.967	0.264
Polygonaceae	*Rumex obtusifolius*	1.710	-0.019	3.069	-1.425
Phrymaceae	*Mimulus guttatus*	3.207	-0.989	2.025	-1.299
Scrophulariaceae	*Scrophularia nodosa*	2.772	-1.022	0.999	-1.044
Plantaginaceae	*Veronica anagallis-aquatica*	3.173	-1.086	3.206	0.323
Plantaginaceae	*Veronica peregrina*	1.268	-1.021	1.620	0.050
Plantaginaceae	*Veronica persica*	2.443	-0.468	2.642	0.020

Table A5. The identified aphid and mollusc species in the study, with details of main host plant species, other families, genera and species used as host plants, other food types, presence in Switzerland, distribution and alien status in Switzerland. Sources are as follows- 1: Lampel, G. and Meier, W. (2007) Hemiptera Sternorrhyncha - Aphidina. Centre Suisse de Cartographie de la Faune, Neuchâtel. 2: Boschi, C. (2011) Die Schneckenfauna der Schweiz, Haupt Verlag. 3: Frömming, E. (1954) Biologie der mitteleuropäischen Landgastropoden. Duncker & Humblot, Berlin. 4: Turner, H. (1998) Atlas der Mollusken der Schweiz und Liechtensteins. Centre Suisse de Cartographie de la Faune, Neuchâtel. 5: Wittenberg, R. & Schweiz Bundesamt Für Umwelt. (2006) Invasive alien species in Switzerland an inventory of alien species and their threat to biodiversity and economy in Switzerland. Federal Office for the Environment FOEN, Berm.

Species	Main host[1]	Other host familes[1]	Host genera[1]	Host species[1,2,3]	Records in Switzerland[1,4]	Distribution[1,4]	Alien? [5]
Aphis frangulae	*Frangula alnus*	Brassicaceae, Lamiaceae, Onagraceae, Convolvulaceae, Lythraceae, Plantaginaceae, Rhamnaceae, Solanaceae	several, for example *Capsella, Epilobium, Galeopsis, Ipomaea, Lamium, Lysimachia, Veronica*	*Solanum tuberosum*	13	palearctic, N-American	
Aulocorthum solani		Extremely polyphagous, but no grasses; certain strains mainly on *Solanum tuberosum*; Asteraceae, Euphorbiaceae, Rosaceae		*Cichorium endivia, Cirsium acaule, Euphorbia exigua, E.stricta, Potentilla grandiflora, Sanguisorba officinalis*	16	cosmopolitan, probably originally European	
Aphis fabae	*Euonymus europaea*	Celastraceae, Fabaceae, Chenopodiaceae		*Vicia faba, Phaseolus spp., Chenopodium spp., Beta vulgaris*	7	Eurasian, N-American	
Macrosiphum euphorbiae		Extremely polyphagous, important families are Asteraceae and Solanaceae		*Solanum tuberosum, Beta vulgaris,*	28	cosmopolitan, nearctic origin	yes, origin N-

				Lactuca sativa			America
Rhophalosiphum nymphaeae	*Prunus* sp.	Acoraceae, Alismataceae, Butomaceae, Araceae, Callitrichaceae, Hydrocharitaceae, Juncaceae, Menyanthaceae, Haloragaceae, Nymphaceae, Poaceae, Polygonaceae, Potamogetonaceae, Ranunculaceae, Cyperaceae, Sparganiaceae, Typhaceae, Lythraceae	several, *Acorus, Alisma, Butomus, Calla, Callitriche, Echinodorus, Elodea, Glyceria, Hippuris, Hydrocharis, Juncus, Lemna, Menyanthes, Myriophyllum, Nelumbo, Nuphar, Nymphaea, Nymphoides, Pistia, Polygonum, Potamogeton, Ranunculus, Sagittaria, Schoenoplectus, Scirpus, Sparganium, Stratiotes, Trapa, Typha, Wedelis,* etc.		12	cosmopolitan	
Myzus persicae	*Prunus* sp.	In CH: Amaranthaceae, Apiaceae, Asteraceae, Boraginaceae, Brassicaceae, Caryophyllaceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Malvaceae, Orobanchaceae, Poaceae, Polygonaceae, Rosaceae, Rubiaceae, Scrophulariaceae, Solanaceae, Tamaricaceae, Violaceae			29	cosmopolitan	yes, probably from Asia
R. padi	*Prunus* sp.	Rosaceae. Also possible on: Cyperaceae, Juncaceae, Typhaceae, Iridaceae, Poaceae, Brassicaceae	several Poaceae, including *Agropyron,*	*Capsella bursa-pastoris*	28	cosmopolitan	

			Agrostis, Arrhenatherum, Avena, Bromus, Calamagrostis, Cynosurus, Dactylis, Deschampsia, Festuca, Glyceria, Helictotrichon, Holcus, Hordelymus, Hordeum, Melica, Phalaris, Phleum, Poa, Triticum, Zea, etc.				
Sitobion avenae		several, but often on Poaceae, Amaranthaceae, Asparagaceae	*Amaranthus, Aspargus, Avena, Calamagrostis, Glyceria, Hordeum, Lagurus, Lolium, Molinia, Phalaris, Poa, Secale, Setaria, Triticum, Zea*		36	cosmopolitan, probably origin westpalaearctic	
Arion vulgaris		higher plants but also faeces and carcasses			abundant, pest		yes, origin unknown
Deroceras reticulatum		higher plants, prefers fresh plants; eats also fungi and carcasses			abundant, pest		
Succinea putris		higher plants, in particular herbs; algae			abundant		
Xerolenta obvia		higher plants, several herbs			abundant		

Table A6. Parameter estimates (and standard errors in parentheses) for binomial generalised linear mixed models of mollusc, orthopteran and thysanopteran presence on non-pesticide treated plants. Results are shown for models including all species (n = 26), and only the nitrophilous species (n = 21). Values for random effects represent standard deviations. Significant estimates ($p < 0.05$) are shown in bold.

	Variable	Mollusc	Orthopteran	Thysanopteran
Fixed effects	Intercept	**-1.782 (0.556)**	**-1.744 (0.590)**	-0.255 (0.794)
	Native	0.217 (0.647)	-0.797 (0.620)	-1.226 (0.697)
	Non-invasive	0.291 (0.688)	-0.505 (0.627)	-0.474 (0.741)
Random effects	Block	0.615	0.311	<0.0001
	Family	0.018	0.943	1.495
	Species	0.915	0.401	0.976

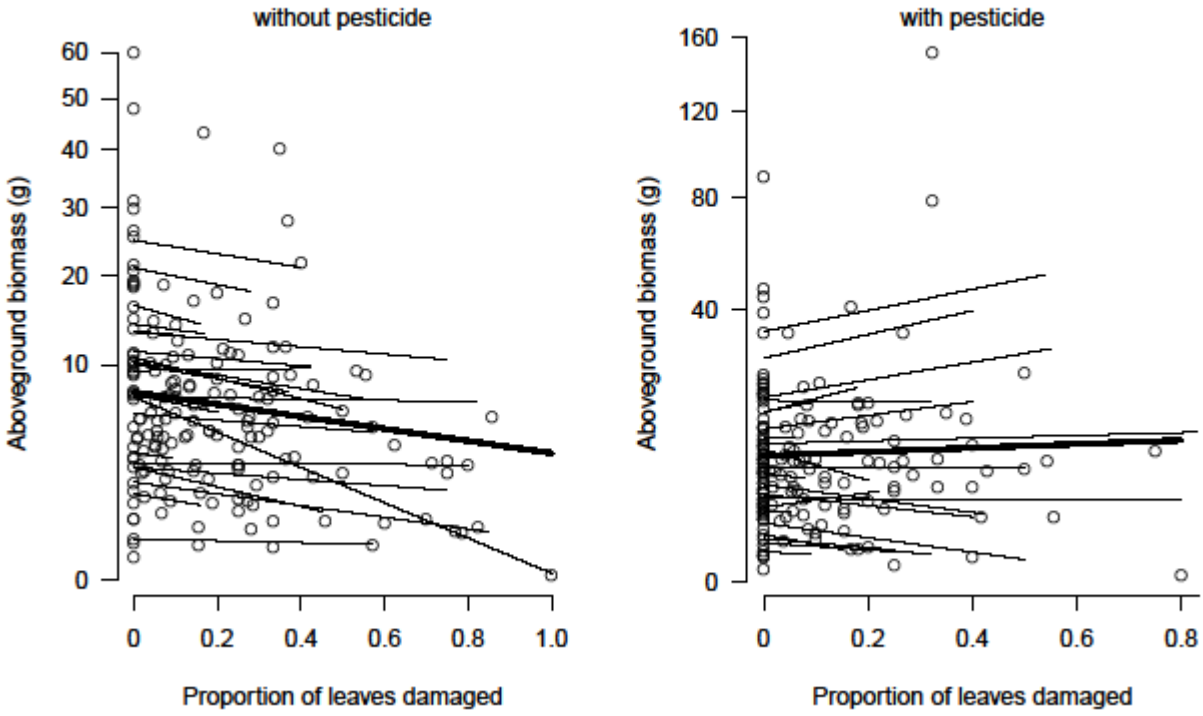

Figure A1. Relationship between aboveground biomass and proportion of leaves damaged on plants without and with pesticide treatment, showing overall fitted relationship (thick line) and individual fitted lines for the 23 species

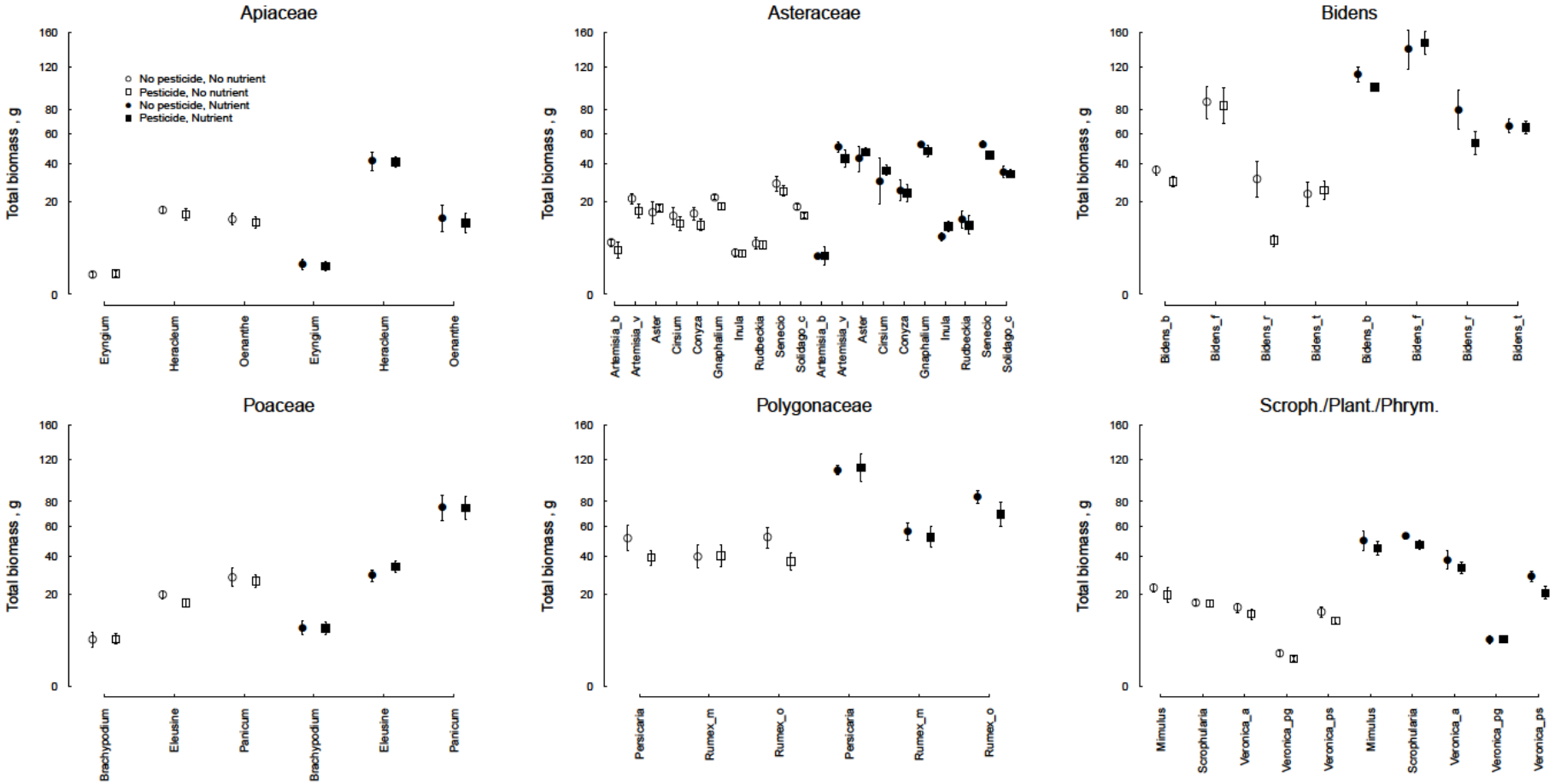

Figure A2. Mean total biomass (square-root scale) of plants with and without pesticide treatment and with and without nutrient addition. Error bars represent ± 1 SE.

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