Electronic supplementary materials:

Table S1 The ecological significance, measuring method, and the corresponding references for the measured seed germination and seedling growth indicators of *L. sativa*.

Measured indices	Ecology significances	Determination methods	References
Germination percentage (%)	Germination competitiveness	The ratio of the number of the normal germinated seeds to the total number of the tested seeds	Wei M, Wang S, Wu BD, Cheng HY, Wang CY. 2020. Combined allelopathy of Canada goldenrod and horseweed on the seed germination and seedling growth performance of lettuce. Landscape and Ecological Engineering 16: 299–306.; Yu YL, Cheng HY, Xu ZL, Zhong SS, Wang CY, Guo EH. 2022. Invasion intensity modulates the allelopathic impact of *Solidago canadensis* L. leaves and roots against *Lactuca sativa* L. during germination and early seedling stage. International Journal of Environmental Research 16: 48.; Yu YL, Cheng HY, Wei M, Wang S, Wang CY. 2022. Silver nanoparticles intensify the allelopathic intensity

			of four invasive plant species in the Asteraceae. Anais da Academia Brasileira de Ciências 94: e20201661.
Germination potential (%)	Germination power	The ratio of the number of the normal germinated seeds to the total number of the tested seeds on the third day	Wei M, Wang S, Wu BD, Cheng HY, Wang CY. 2020. Combined allelopathy of Canada goldenrod and horseweed on the seed germination and seedling growth performance of lettuce. Landscape and Ecological Engineering 16: 299–306.; Yu YL, Cheng HY, Xu ZL, Zhong SS, Wang CY, Guo EH. 2022. Invasion intensity modulates the allelopathic impact of *Solidago canadensis* L. leaves and roots against *Lactuca sativa* L. during germination and early seedling stage. International Journal of Environmental Research 16: 48.; Yu YL, Cheng HY, Wei M, Wang S, Wang CY. 2022. Silver nanoparticles intensify the allelopathic intensity of four invasive plant species in the Asteraceae. Anais da Academia Brasileira de Ciências 94: e20201661.
Germination	Germination	Germination index = $\sum G_i$	Schmer MR, Xue Q, Hendrickson JR. 2012. Salinity effects on perennial, warm-season (C4)

index	activity	/ *I*, where G_i means the number of the normal germinated seeds and *I* means the time after cultivation (day)	grass germination adapted to the northern Great Plains. Canadian Journal of Plant Science 92: 873–881.; Hou QQ, Chen BM, Peng SL, Chen LY. 2014. Effects of extreme temperature on seedling establishment of nonnative invasive plants. Biological Invasions 16: 2049–2061.; Fang ZG, Hu ZY, Zhao HH, Yang L, Ding CL, Lou LQ, Cai QS. 2017. Screening for cadmium tolerance of 21 cultivars from Italian ryegrass (*Lolium multiflorum* Lam) during germination. Grassland Science 63: 36–45.; Tan M, Liao F, Hou LT, Wang J, Wei LJ, Jian HJ, Xu XF, Li JN, Liu LZ. 2017. Genome-wide association analysis of seed germination percentage and germination index in *Brassica napus* L. under salt and drought stresses. Euphytica 213: 40.; Ding TL, Yang Z, Wei XC, Yuan F, Yin SS, Wang BS. 2018. Evaluation of salt-tolerant germplasm and screening of the salt-tolerance traits of sweet sorghum in the germination stage. Functional Plant Biology 45: 1073–1081.
Germination	Germination	The arithmetic product of	Steinmaus SJ, Timonthy SP, Jodie SH. 2000. Estimation of base temperature for nine weed

rate index	strength	the two values of germination percentage and germination index	species. Journal of Experimental Botany 51: 275–286.; Qiu J, Bai YG, Fu YB, Wilmshurstc JF. 2010. Spatial variation in temperature thresholds during seed germination of remnant *Festuca hallii* populations across the Canadian prairie. Environmental and Experimental Botany 67: 479–486.; Mollard FPO, Naeth MA. 2014. Photoinhibition of germination in grass seed-Implications for prairie revegetation. Journal of Environmental Management 14: 1–9.
Germination vigor index	Germination vitality	The arithmetic product of the two values of germination index and seedling biomass (fresh weight)	Lin WX, Kim KU, Smin DH. 2000. Rice allelopathic potential and its modes of action on barnyardgrass (*Echinochloa crus-galli*). Allelopathy Journal 7: 215–224.; Li Z, Peng Y, Zhang XQ, Ma X, Hang LK, Yan YH. 2014. Exogenous spermidine improves seed germination of white clover under water stress via involvement in starch metabolism, antioxidant defenses and relevant gene expression. Molecules 19: 18003–18024.; Ding TL, Yang Z, Wei XC, Yuan F, Yin SS, Wang BS. 2018. Evaluation of salt-tolerant germplasm and screening of the salt-tolerance traits of sweet sorghum in the germination stage. Functional Plant Biology 45:

			1073–1081.
Promptness index	Germination rapid response capability	Promptness index = (1.00) * nd_2 + (0.75) * nd_4 + (0.50) * nd_6 + (0.25) * nd_8, where nd_2, nd_4, nd_6, and nd_8 are the number of the normal germinated seeds in the second, fourth, sixth, and eighth days after cultivation, respectively.	Grzesiak S. 2001. Genotypic variation between maize (*Zea mays* L.) single cross hybrids in response to drought stress. Acta Physiologiae Plantarum 23: 443–456.; Noreen Z, Ashraf M, Hassan MU. 2007. Inter-accessional variation for salt tolerance in pea (*Pisum sativum* L.) at germination and screening stage. Pak. J. Bot. 39: 2075–2085.; Asci OO. 2011. Salt tolerance in red clover (*Trifolium pratense* L.) seedlings. African Journal of Biotechnology 10: 8774–8781.; Toscano S, Romano D, Tribulato A, Patane C. 2017. Effects of drought stress on seed germination of ornamental sunflowers. Acta Physiologiae Plantarum 39: 184.
Seedling	Competitiveness	A ruler with 0.1 cm	Wei M, Wang S, Wu BD, Cheng HY, Wang CY. 2020. Combined allelopathy of Canada

height (cm)	for sunlight acquisition	accuracy (the distance between the base of the stem and the apical shoot)	goldenrod and horseweed on the seed germination and seedling growth performance of lettuce. Landscape and Ecological Engineering 16: 299–306.; Yu YL, Cheng HY, Xu ZL, Zhong SS, Wang CY, Guo EH. 2022. Invasion intensity modulates the allelopathic impact of *Solidago canadensis* L. leaves and roots against *Lactuca sativa* L. during germination and early seedling stage. International Journal of Environmental Research 16: 48.; Yu YL, Cheng HY, Wei M, Wang S, Wang CY. 2022. Silver nanoparticles intensify the allelopathic intensity of four invasive plant species in the Asteraceae. Anais da Academia Brasileira de Ciências 94: e20201661.
Radicle length (cm)	Competitiveness for water and inorganic salt acquisition	A ruler with 0.1 cm accuracy (the distance between the base of the radicle and the radicle	Wei M, Wang S, Wu BD, Cheng HY, Wang CY. 2020. Combined allelopathy of Canada goldenrod and horseweed on the seed germination and seedling growth performance of lettuce. Landscape and Ecological Engineering 16: 299–306.; Yu YL, Cheng HY, Xu ZL, Zhong SS, Wang CY, Guo EH. 2022. Invasion intensity modulates the allelopathic impact of

		tip)	*Solidago canadensis* L. leaves and roots against *Lactuca sativa* L. during germination and early seedling stage. International Journal of Environmental Research 16: 48.; Yu YL, Cheng HY, Wei M, Wang S, Wang CY. 2022. Silver nanoparticles intensify the allelopathic intensity of four invasive plant species in the Asteraceae. Anais da Academia Brasileira de Ciências 94: e20201661.
Leaf dimensions (i.e., leaf length and width) (cm)	Leaf photosynthetic area	A ruler with 0.1 cm accuracy (the maximum value along the midrib and the maximum value perpendicular to the midrib, respectively)	Wei M, Wang S, Wu BD, Cheng HY, Wang CY. 2020. Combined allelopathy of Canada goldenrod and horseweed on the seed germination and seedling growth performance of lettuce. Landscape and Ecological Engineering 16: 299–306.; Yu YL, Cheng HY, Xu ZL, Zhong SS, Wang CY, Guo EH. 2022. Invasion intensity modulates the allelopathic impact of *Solidago canadensis* L. leaves and roots against *Lactuca sativa* L. during germination and early seedling stage. International Journal of Environmental Research 16: 48.; Yu YL, Cheng HY, Wei M, Wang S, Wang CY. 2022. Silver nanoparticles intensify the allelopathic intensity

			of four invasive plant species in the Asteraceae. Anais da Academia Brasileira de Ciências 94: e20201661.
Green leaf area (cm^2)	Leaf photosynthetic area	Green leaf area = leaf length × leaf width × 0.75	Rybinski W, Garczynski S. 2004. Influence of laser light on leaf area and parameters of photosynthetic activity in DH lines of spring barley (*Hordeum vulgare* L.). International Agrophysics 18: 261–267.; Amanullah, Marwat KB, Shah P, Maula N, Arifullah S. 2009. Nitrogen levels and its time of application influence leaf area, height and biomass of maize planted at low and high density. Pakistan Journal of Botany 41: 761–768.; Xia TT, Miao YX, Wu DL, Shao H, Khosla R, Mi GH. 2016. Active optical sensing of spring maize for in-season diagnosis of nitrogen status based on nitrogen nutrition index. Remote Sensing 8: 605.; Huang SS, Sun LQ, Hu X, Wang YH, Zhang YJ, Nevo E, Peng JH, Sun DF. 2018. Associations of canopy leaf traits with SNP markers in durum wheat (*Triticum turgidum* L. *durum* (Desf.)). PLoS One 13: e206226.

Seedling biomass (including wet and dry weights) (g)	Plant growth competitiveness	An electronic balance with 0.001 g accuracy	Wei M, Wang S, Wu BD, Cheng HY, Wang CY. 2020. Combined allelopathy of Canada goldenrod and horseweed on the seed germination and seedling growth performance of lettuce. Landscape and Ecological Engineering 16: 299–306.; Yu YL, Cheng HY, Xu ZL, Zhong SS, Wang CY, Guo EH. 2022. Invasion intensity modulates the allelopathic impact of *Solidago canadensis* L. leaves and roots against *Lactuca sativa* L. during germination and early seedling stage. International Journal of Environmental Research 16: 48.; Yu YL, Cheng HY, Wei M, Wang S, Wang CY. 2022. Silver nanoparticles intensify the allelopathic intensity of four invasive plant species in the Asteraceae. Anais da Academia Brasileira de Ciências 94: e20201661.
Moisture content (%)	Plant water content	The ratio of the difference between fresh weight per seedling and	Wei M, Wang S, Wu BD, Cheng HY, Wang CY. 2020. Combined allelopathy of Canada goldenrod and horseweed on the seed germination and seedling growth performance of lettuce. Landscape and Ecological Engineering 16: 299–306.; Yu YL, Cheng HY, Xu ZL,

		dry weight per seedling to fresh weight per seedling	Zhong SS, Wang CY, Guo EH. 2022. Invasion intensity modulates the allelopathic impact of *Solidago canadensis* L. leaves and roots against *Lactuca sativa* L. during germination and early seedling stage. International Journal of Environmental Research 16: 48.; Yu YL, Cheng HY, Wei M, Wang S, Wang CY. 2022. Silver nanoparticles intensify the allelopathic intensity of four invasive plant species in the Asteraceae. Anais da Academia Brasileira de Ciências 94: e20201661.
Stress intensity index	The stress intensity of different treatments on the seed germination and seedling	Stress intensity index = 1 – (X_s / X_{ns}), where X_s and X_{ns} mean the average plant performance measures under the condition with stress and	Tern H, Singh SP. 2002. Comparison of sources and lines selected for drought resistance in common bean. Crop Science 42: 64–70.; Zangi MR. 2005. Correlation between drought resistance indices and cotton yield in stress and non stress conditions. Asian Journal of Plant Sciences 4: 106–108.; Anwar J, Subhani GM, Hussain M, Ahmad J, Hussain M, Munir M. 2011. Drought tolerance indices and their correlation with yield in exotic wheat genotypes. Pakistan Journal of Botany 43: 1527–1530.; Zdravković J, Jovanović Z, Đorđević M, Girek Z,

growth	the condition without stress, respectively. The value of the index ranged from zero to one, and the index illustrates a stronger stress intensity if its value is close to one. In contrast, the intensity of stress is weaker if its value is close to zero.	Zdravković M, Stikić R. 2013. Application of stress susceptibility index for drought tolerance screening of tomato populations. Genetika 45: 679–689.; Ballesta P, Mora F, Pozo AD. 2020. Association mapping of drought tolerance indices in wheat: QTL-rich regions on chromosome 4A. Scientia Agricola, 77: e20180153.

Table S2 Two-way ANOVA showing the effect of the main factors: the form of nitrogen solution, and the type of aqueous leaf extracts, and their interactions on the indicators of lettuce. *P* values equal to or less than 0.05 are shown in bold.

		Sum of Squares	df	Mean Square	*F*	*P*	η^2
The form of nitrogen solution	Germination percentage	544.7738	4	136.1935	3.9254	**0.0092**	0.2924
	Germination potential	3660.0716	4	915.0179	13.7264	**<0.0001**	0.5910
	Germination index	636.3049	4	159.0762	14.1490	**<0.0001**	0.5983
	Germination rate index	708.5998	4	177.1499	10.3259	**<0.0001**	0.5208
	Germination vigor index	34.3837	4	8.5959	30.4251	**<0.0001**	0.7621
	Promptness index	757.3781	4	189.3445	9.3982	**<0.0001**	0.4973
	Seedling height	2.4451	4	0.6113	51.1547	**<0.0001**	0.8434
	Radicle length	1.1473	4	0.2868	5.7342	**0.0010**	0.3764
	Leaf length	0.8020	4	0.2005	66.1180	**<0.0001**	0.8744
	Leaf width	0.0786	4	0.0196	54.2922	**<0.0001**	0.8511
	Green leaf area	0.1993	4	0.0498	80.3960	**<0.0001**	0.8943

	Seedling fresh weight	0.0195	4	0.0049	63.9673	**<0.0001**	0.8707
	Seedling dry weight	<0.0001	4	<0.0001	5.9061	**0.0008**	0.3834
	Moisture content	48.7727	4	12.1932	24.0324	**<0.0001**	0.7167
	Stress intensity index	0.0955	4	0.0239	12.6991	**<0.0001**	0.5721
The type of	Germination percentage	1632.1750	3	544.0583	15.6808	**<0.0001**	0.5532
aqueous leaf	Germination potential	17143.4577	3	5714.4859	85.7240	**<0.0001**	0.8713
extracts	Germination index	13635.7629	3	4545.2543	404.2777	**<0.0001**	0.9696
	Germination rate index	14524.7126	3	4841.5709	282.2100	**<0.0001**	0.9570
	Germination vigor index	279.5527	3	93.1842	329.8228	**<0.0001**	0.9630
	Promptness index	6131.7958	3	2043.9319	101.4513	**<0.0001**	0.8890
	Seedling height	0.2981	3	0.0994	8.3165	**0.0002**	0.3963
	Radicle length	2.0856	3	0.6952	13.8982	**<0.0001**	0.5232

	Leaf length	0.0636	3	0.0212	6.9943	**0.0007**	0.3557
	Leaf width	0.0194	3	0.0065	17.8993	**<0.0001**	0.5856
	Green leaf area	0.0190	3	0.0063	10.2367	**<0.0001**	0.4470
	Seedling fresh weight	0.0029	3	0.0010	12.7614	**<0.0001**	0.5019
	Seedling dry weight	<0.0001	3	<0.0001	16.3138	**<0.0001**	0.5629
	Moisture content	5.4546	3	1.8182	3.5836	**0.0224**	0.2205
	Stress intensity index	1.0362	3	0.3454	183.6992	**<0.0001**	0.9355
The form of	Germination percentage	2114.1456	11	192.1951	5.5394	**<0.0001**	0.6159
nitrogen solution	Germination potential	18291.0603	11	1662.8237	24.9443	**<0.0001**	0.8784
* The type of	Germination index	2430.4021	11	220.9456	19.6520	**<0.0001**	0.8505
aqueous leaf	Germination rate index	3142.3002	11	285.6637	16.6510	**<0.0001**	0.8282
extracts	Germination vigor index	75.3497	11	6.8500	24.2453	**<0.0001**	0.8753

Promptness index	2789.4125	11	253.5830	12.5867	**<0.0001**	0.7846
Seedling height	1.7108	11	0.1555	13.0154	**<0.0001**	0.7903
Radicle length	6.0620	11	0.5511	11.0173	**<0.0001**	0.7613
Leaf length	0.5080	11	0.0462	15.2282	**<0.0001**	0.8151
Leaf width	0.0683	11	0.0062	17.1624	**<0.0001**	0.8324
Green leaf area	0.1348	11	0.0123	19.7741	**<0.0001**	0.8513
Seedling fresh weight	0.0137	11	0.0012	16.2923	**<0.0001**	0.8251
Seedling dry weight	<0.0001	11	<0.0001	1.1242	0.3703	0.2455
Moisture content	52.8682	11	4.8062	9.4729	**<0.0001**	0.7328
Stress intensity index	0.5147	11	0.0468	24.8844	**<0.0001**	0.8781

Figure S1 The co-invasion of *Conyza canadensis* (L.) Cronq. and *Solidago canadensis* L. in the same habitat (by Congyan Wang).