Kin recognition in non-native plants: a general hypothesis of invasiveness

Rameez Ahmad[1], Yanjie Liu[1*]

[1]Jilin Da'an Agro-ecosystem National Observation and Research Station; Key Laboratory of Marsh Wetland Ecosystem Conservation and Restoration, National Forestry and Grassland Administration; State Key Laboratory of Black Soils Conservation and Utilization, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Changchun, 130102, China.

ORCID: Rameez Ahmad, https://orcid.org/0000-0002-4229-986X

ORCID: Yanjie Liu, https://orcid.org/0000-0003-3948-1246

*Correspondence author: Yanjie Liu, Email: liuyanjie@iga.ac.cn

Abstract

Understanding how non-native plants successfully invade new environments is a fundamental question in invasion ecology. Here, we propose a novel hypothesis of kin recognition - *the ability of plants to differentiate between closely related and distantly related neighbors* - as a mechanistic explanation for invasion success. To evaluate the idea, we reviewed existing evidence for kin recognition in the plant invasion literature and synthesize supporting findings. Finally, we outline promising research directions that could advance our understanding of kin recognition in plant invasions and help clarify this emerging conceptual framework.

Key words: Alien plant, competition, exotic, facilitation, kin recognition

In the Anthropocene, invasive non-native species are amongst the major drivers of biodiversity loss and ecosystem degradation, with severe ecological, economic, and health repercussions (Pyšek et al., 2020; Diagne et al., 2021; Roy et al., 2023; Thakur et al., 2025). Several hypotheses have been proposed to explain plant invasion mechanisms (Enders et al., 2020), offering valuable insights into why invasive species often outcompete native ones. However, these hypotheses predominantly focus on inter-specific interactions and fail to adequately address the role of intra-specific interactions in driving invasiveness. Specifically, they cannot explain why invasive plants frequently form high-density monocultures over large areas—exceeding both their native range densities and those of co-occurring native species—since such patterns are largely shaped by intra-specific competition.

A potentially significant yet understudied factor affecting non-native plant invasiveness is kin recognition - *the ability of plants to distinguish closely related (kin) from distantly related (sibling) neighbors* (Anten & Chen, 2021a, b). It may affect invasiveness by modulating the intensity and outcome of intra-specific competition. In this paper, we first introduce the concept of kin recognition in plants and then propose a novel hypothesis regarding kin recognition as a mechanism for invasion success of non-native plants in novel ecosystems. Recognizing genetic relatives allows non-native plants to optimize resource acquisition, refine competitive strategies, and form cooperative alliances, all of which increase fitness at the stand level and strengthen their establishment in new environments. We then evaluate the evidence of kin recognition in plant invasion literature, highlight knowledge gaps and suggest promising directions for future research.

Kin recognition and its pathways in plants

The concept of kin recognition, although originally proposed for the animal kingdom (Waldman, 1988; Penn & Frommen, 2010), has gained attention in plant literature in the recent past (Dudley & File, 2007; Dudley et al., 2013; Crepy & Casal, 2015; 2016; Anten et al., 2021a, b). Substantial evidence is now available for the existence of kin recognition in plants, from angiosperms to gymnosperms and including both wild species and crop plants (e.g., Anten et al., 2021a, b; Sher et al., 2025; Xia et al., 2025). By recognizing genetically related neighbors, plants can modify their behavior in ways that reduce competition and enhance reproduction, ultimately benefiting the population as a whole (Karban et al., 2013; Torices et al., 2018; Milla et al., 2019). For example, studies have indicated that plants exhibit less competitive behavior when interacting with kin as compared to strangers (Yang et al., 2018; Takigahira & Yamawo, 2019). Likewise, a recent meta-analytical study revealed that kin recognition in plants reduced below-ground competition by decreasing root biomass and length, root-shoot ratio, and lateral root number, but enhanced above-ground light acquisition traits such as leaf area and boosted reproductive success by increasing seed biomass (Xia et al., 2025). These findings suggest that kin recognition in plants can influence fundamental ecological processes, such as plant trait evolution, community structure, and diversity, and associated ecological interactions (Anten et al., 2021a).

Kin recognition in plants occurs through a series of interlinked events allowing individuals to distinguish closely related from distantly related neighbors and adjust their growth pattern and behaviour accordingly (Biedrzycki & Bais, 2010; Sher et al., 2025). The process starts when one plant individual (i.e., sender) releases a signal in the surrounding environment. Next, a neighboring individual (i.e., receiver) from the population detects and interprets the signal. Finally, the receiving individual reacts to the signal by showing a favorable response towards kin through co-operative or altruistic behaviour, with the latter benefiting population as a whole even at the cost to senders' individual fitness (Sher et al., 2025). Plant signaling has been recognized as a critical factor in kin recognition allowing individuals to detect or perceive genetically related neighbors (Biedrzycki & Bais, 2010; Sher et al. 2025). The plant signals to detect genetically related neighbors are highly variable across species, and are categorized into four broad categories: root exudates (i.e., complex organic secretions from roots) (Yang et al., 2018; Wang et al., 2020), volatile organic compounds (i.e., carbon-based volatile chemical secretions) (Rahman et al., 2019; Ninkovic et al., 2021), light profiles (i.e., light quality cues such as red: far-red (R:FR) light ratio change) (Crepy & Casal, 2015; Chen et al., 2023), and common mycorrhizal networks (i.e., below-ground plant-mycorrhizal symbiotic associations) (Song et al., 2015; Chagas et al., 2018).

Kin recognition: a general hypothesis of invasiveness

In the introduced range, the invasion success of non-native plants is primarily determined by both inter-specific and intra-specific competition for limiting resources with neighboring plants (Zhang et al., 2022). While inter-specific competition may lead to competitive exclusion of native species, intra-specific competition can also induce a self-limiting effect (Mangla et al., 2011; Boström-Einarsson et al., 2013; Kula et al., 2020). Yet, invasive plants are frequently observed to form extensive, high-density stands that exceed both their densities in native range, and those of co-occurring native plants (Zheng et al., 2015; Iqbal et al., 2020; Zhao et al., 2020). To resolve this paradox, we propose that kin recognition serves as a critical mechanism influencing invasiveness (**Figure 1**). A heightened ability to identify genetically related individuals could allow invasive plants to reducing competition among close relatives, even foster cooperative or altruistic behaviors, wherein individuals act to benefit the population or closely related conspecifics, sometimes at a cost to themselves (**Figure 1**). Consequently, invasive populations often exhibit reduced competition and improved overall fitness when grown with kin compared to non-kin, ultimately facilitating the formation of high-density monocultures (**Figure 1**). We conduct a systematic literature search using Web of Science (https://www.webofscience.com) and Scopus (https://www.scopus.com). Of the relevant studies identified, all the eight studies provided at least partial evidence supporting the existence of kin recognition in invasive plants (see Supporting Information).

Evolution of kin recognition in non-native plants

Recent studies have confirmed that invasive plant species possess the ability to discriminate between kin and non-kin neighbors. For instance, the invasive *Xanthium italicum* reduces its root biomass and competitive intensity when grown with kin compared to non-kin (Abd El-Gawad et al., 2017). Similarly, the clonal invasive *Kalanchoë daigremontiana* produces more plantlets when competing with kin than with non-kin (Yamawo et al. 2017). Consistent with the observation that the invasive *Potentilla recta* perform better among kin under low-water conditions, kin-conditioned soil has also been shown to enhance survival and growth under drought (Wu et al., 2021). Furthermore, the invasive rosette species garlic mustard (*Alliaria petiolata*) exhibits kin recognition, manifested as increased petiole elongation and specific leaf area among siblings, a morphological adjustment that reduces mutual shading and reflects cooperative behavior (Murphy et al., 2022). Collectively, this evidence indicates that kin recognition occurs in non-native plants within their introduced ranges. This ability may represent an evolved response or an inherent trait that facilitates invasion success.

Multiple selective pressures in introduced ranges likely drive the evolution of enhanced kin recognition in invasive plants. First, following introduction, founder effect frequently reduces genetic diversity in non-native plant populations (Dlugosch & Parker, 2008; Colautti et al., 2010; Lee et al., 2021). In response, plants may shift toward self-pollination or clonal propagation (Liu et al., 2006; Razanajatovo et al., 2016; Yamawo et al., 2017). Under such conditions, selection may favor the evolution of kin recognition and reduced competitive or even facilitative responses towards their kin (Yamawo et al., 2017; Zhang et al., 2019; Lee et al., 2021). Such responses are often adaptive, promoting inclusive fitness through cooperative behaviour among genetically related individuals. Second, invasive plant species frequently form high-density, clustered populations in their introduced ranges (Zheng et al., 2021). Under such conditions, intense intra-specific competition can become a major constraint on population growth (Chesson, 2000). To persist and spread, invasive plants must alleviate such intra-specific competition. Kin recognition offers an effective mechanism to reduce competitive costs among relatives, thereby enhancing population fitness and strengthening competitive advantage over native plants (Zhang et al., 2019; Zheng et al., 2021).

Indeed, limited but suggestive evidence indicates that kin recognition may evolve in invasive populations of non-native species. For example, Zhang et al. (2019) found that introduced genotypes of *Alternanthera philoxeroides* produced more branches when grown in competition with kin (i.e., same genotype) compared to when competing with non-kin (i.e., different genotypes), whereas the native genotypes showed the opposite response. Moreover, introduced genotypes produced longer stems when grown in competition with con-specifics compared to growing alone, whereas native genotypes produced shorter stems. This indicates that introduced genotypes exhibit better shade-avoidance responses to competition from con-specifics than native genotypes. Such reduced intra-specific aggression among kin potentially increased the stand level fitness of *A. philoxeroides* during early stages of invasion, and subsequently promotes its establishment and spread in the introduced range (Zhang et al., 2019). Additionally, invasive populations growing with kin produced more branches, suggesting that kin recognition may facilitate resource allocation from vegetative growth to reproduction, thereby accelerating their spread in novel environments. Overall, this study provides compelling evidence that kin interaction in *A. philoxeroides* have shifted from competition in its native range (i.e., Argentina) to facilitation in the invasive range (i.e., United States), driven by a higher frequency of interactions following introduction (Zhang et al., 2019).

Kin recognition difference between invasive and native plants

Given that invasive non-native plants often occupy larger areas and establish denser populations than native counterparts (Zheng et al., 2015; Iqbal et al., 2020; Zhao et al., 2020), we hypothesize that they may possess a superior ability for kin recognition. Since kin recognition can decrease intra-specific competition, this enhanced capacity could confer a demographic advantage on invasive plants, thereby driving their invasion success. Nevertheless, kin recognition ability can vary across populations within same species. For example, variation in kin recognition has been observed among populations of both invasive *Taraxacum officinale* and native *T. platycarpum*, with populations from similar habitats sometimes showing convergent responses (Lee et al. 2021). This may because the selection pressures differ for varied populations. Indeed, Zheng et al. (2021) demonstrated that the invasive *Eupatorium adenophorum* exhibits stronger kin recognition than its native congeners (*E. fortunei* and *E. lindleyanum*) under high-density conditions. This relatively higher kin recognition allows invasive plants to mitigate intra-specific competition by optimizing resource allocation, for example, by reducing carbon investment in roots while increasing height to enhance light capture efficiency (Zheng et al., 2021; Chen et al., 2023). Such adjustments collectively improve stand-level population fitness, reinforcing their competitive dominance. A recent study reveals a clear divergence in kin-mediated growth strategies between invasive and native congeneric species (Li et al., 2026). In the invasive *Alternanthera philoxeroides*, competitive allocation (longer stolons, more nodes and branches) toward neighbors was reduced among kin, boosting stand-level performance. This is evidence of functional kin recognition. In contrast, the native *A. sessilis* intensified such competitive traits within kin groups, suggesting weaker or absence of kin recognition. Together, by adjusting resource allocation strategies based on neighbor identity, non-native plants can optimize resource use, facilitate survival and intensify spread in the introduced ranges, ultimately contributing to their ecological dominance.

Conclusion and way forward

We propose a novel hypothesis that kin recognition promotes plant invasiveness by reducing competition among genetically related individuals, thus facilitating the establishment of high-density populations. We concluded that current body of relevant experimental evidence is sufficient to firmly support the evidence of kin recognition in invasive plants. Future work should expand kin recognition research to a broader suite of invasive species, include more genotypes across a gradient of genetic relatedness, and examine how genetic diversity influences kin-mediated interactions. Furthermore, long-term field experiments are essential to understand how kin recognition regulates plant invasions under global environmental changes.

Acknowledgments

Yanjie Liu acknowledges funding from National Natural Science Foundation of China (W2411021; 32371748).

Declaration of interests

The authors declare no competing interests.

Author contributions

YL conceived the idea and design the framework of the study. RA and YL wrote the manuscript.

Declaration of generative AI and AI-assisted technologies in the writing process

During the writing process, the first author used ChatGPT (www.chatgpt.com) to improve the clarity and language of the manuscript. The author(s) reviewed and edited the content as needed, and take full responsibility for the content of the publication.

References

Abd El-Gawad, A.M., Zotti, M., Sarker, T.C., Mazzoleni, S., & Bonanomi, G. (2017). Does a plant detect its neighbor if it is kin or stranger? Evidence from a common garden experiment. *Community Ecology*, 18: 305–310.

Anten, N.P., & Chen, B.J. (2021a). Detect thy family: mechanisms, ecology and agricultural aspects of kin recognition in plants. *Plant, Cell & Environment*, 44: 1059–1071.

Anten, N.P., & Chen, B.J. (2021b). Kin discrimination in allelopathy and consequences for agricultural weed control. *Plant, Cell & Environment*, 44: 3705.

Biedrzycki, M.L., Jilany, T.A., Dudley, S.A., & Bais, H.P. (2010). Root exudates mediate kin recognition in plants. *Communicative & Integrative Biology*, 3: 28–35.

Boström-Einarsson, L., Bonin, M.C., Munday, P.L., & Jones, G.P. Strong intraspecific competition and habitat selectivity influence abundance of a coral-dwelling damselfish. *Journal of Experimental Marine Biology and Ecology.* 448: 85–92.

Chagas, F.O., de Cassia, Pessotti. R., Caraballo-Rodriguez, A.M., & Pupo, M.T. (2018). Chemical signaling involved in plant–microbe interactions. *Chemical Society Reviews*, 47: 1652–1704.

Chen, L., Pan, Y., Pan, X., Yu, L., Sosa, A., Yang, J., & Li, B. (2023). From competition to cooperation: Kin selection against selfish shade avoidance behaviour promotes plant invasions. *Journal of Ecology,* 111: 645–654.

Chesson, P. (2000). Mechanisms of maintenance of species diversity. *Annual Review of Ecology and Systematics*, 31: 343–366.

Colautti, R.I., Eckert, C.G., & Barrett, S.C. (2010). Evolutionary constraints on adaptive evolution during range expansion in an invasive plant. *Proceedings of the Royal Society B: Biological Sciences*, 277: 1799–1806.

Crepy, M.A., & Casal, J.J. (2015). Photoreceptor-mediated kin recognition in plants. *New Phytologist*, 205: 329–338.

Crepy, M.A., & Casal, J.J. (2016). Kin recognition by self-referent phenotype matching in plants. New Phytologist, 209: 15–6.

Diagne, C., Leroy, B., Vaissière, A.C., Gozlan, R.E., Roiz, D., Jarić, I., ... & Courchamp, F. (2021). High and rising economic costs of biological invasions worldwide. *Nature*, 592: 571–576.

Dlugosch, K.M., & Parker, I.M. (2008). Founding events in species invasions: Genetic variation, adaptive evolution, and the role of multiple introductions. *Molecular Ecology*, 17: 431–449.

Dudley, S.A., & File, A.L. (2007). Kin recognition in an annual plant. *Biology Letters*, 3: 435–438.

Dudley, S.A., Murphy, G.P., & File, A.L. (2013). Kin recognition and competition in plants. *Functional Ecology*, 27: 898–906.

Enders, M., Havemann, F., Ruland, F., Bernard-Verdier, M., Catford, J.A., Gómez-Aparicio, L., … & Jeschke, J.M. (2020). A conceptual map of invasion biology: Integrating hypotheses into a consensus network. *Global Ecology and Biogeography*, 29: 978–991.

Iqbal, M.F., Liu, M.C., Iram, A., & Feng, Y.L. (2020). Effects of the invasive plant *Xanthium strumarium* on diversity of native weed species: a competitive analysis approach in North and Northeast China. *PLoS ONE,* 15: e0228476.

Karban, R., Shiojiri, K., Ishizaki, S., Wetzel, W.C., & Evans, R.Y. (2013). Kin recognition affects plant communication and defence. *Proceedings of the Royal Society B: Biological Sciences,* 280: 20123062.

Kula, A.A.R., Hey, M.H., Couture, J.J. Townsend, P.A., & Dalgleish, H.J. (2020). Intraspecific competition reduces plant size and quality and damage severity increases defense responses in the herbaceous perennial, *Asclepias syriaca*. *Plant Ecology*, 221: 421–430.

Lee, S., Woo, S., & Kim, E. (2021). Differential effect of inter-and intra-specific competition on the performance of invasive and native *Taraxacum* species. *Plant Species Biology*, 36: 187–197.

Li, Y., & Xu, X. (2026). Differential kin interactions between invasive and native plants: Evidence from Alternanthe philoxeroides and its native congener. Preprint.

Liu, J., Dong, M., Miao, S.L., Li, Z.Y., Song, M.H., & Wang, R.Q. (2006). Invasive alien plants in China: role of clonality and geographical origin. *Biological Invasions*, 8: 1461–1470.

Mangla, S., Sheley, R.L., James, J.J., Radosevich, S.R. (2011). Intra and interspecific competition among invasive and native species during early stages of plant growth. *Plant Ecology*, 212: 531–542

Milla, R., Forero, D.M., Escudero, A., & Iriondo, J.M. (2019). Growing with siblings: A common ground for cooperation or for fiercer competition among plants? *Proceedings of the Royal Society B: Biological Sciences*, 276: 2531–2540.

Murphy, G.P., Shah, R., & Dudley, S.A. (2022). Comparison of competitive behaviours between native and invasive ecotypes of garlic mustard under different density conditions, presence and identity of neighbours. *Botany*, 100: 761–769.

Ninkovic, V., Markovic, D., & Rensing, M. (2021). Plant volatiles as cues and signals in plant communication. *Plant, Cell & Environment*, 44: 1030–1043.

Penn, D.J., & Frommen, J.G. (2010). Kin recognition: an overview of conceptual issues, mechanisms and evolutionary theory. In: Kappeler, P., ed. *Animal behavior: evolution and mechanisms*. Berlin, Heidelberg: Springer, pp. 55–85.

Pyšek, P., Hulme, P.E., Simberloff, D., Bacher, S., Blackburn, T.M., … & Richardson, D.M. (2020). Scientists' warning on invasive alien species. *Biological Reviews*, 95: 1511–1534.

Rahman, M.K.U., Zhou, X.G., & Wu, F.Z. (2019). The role of root exudates, CMNs, and VOCs in plant-plant interaction. *Journal of Plant Interactions*, 14: 630–636.

Razanajatovo, M., Maurel, N., Dawson, W., Essl, F., Kreft, H., Pergl, J., … & van Kleunen, M. (2016). Plants capable of selfing are more likely to become naturalized. *Nature Communications*, 7: 13313.

Roy, H.E., Pauchard, A., Stoett, P., Truong, T.R., Bacher, S., Galil, B.S., ... & Vandvik, V. (2023). IPBES invasive alien species assessment: summary for policymakers. *IPBES*.

Sher, J., Zheng, Y.L., Burns, J.H., Jan, G., & Zhang, J.L. (2025). Kin recognition in plants-an ecological perspective: an overview of plant kin recognition under different resources, consequences and future challenges. *Journal of Plant Interactions*, 20: 2548579.

Song, Y.Y., Simard, S.W., Carroll, A., Mohn, W.W., & Zeng, R.S. (2015). Defoliation of interior Douglas-fir elicits carbon transfer and stress signalling to ponderosa pine neighbors through ectomycorrhizal networks. *Scientific Reports*, 5:1–9.

Takigahira, H., & Yamawo, A. (2019). Competitive responses based on kin-discrimination underlie variations in leaf functional traits in Japanese beech (*Fagus crenata*) seedlings. *Evolutionary Ecology*, 33: 521–531.

Thakur, M.P., Gu, Z., van Kleunen, M., & Zhou, X. (2025). Invasion impacts in terrestrial ecosystems: global patterns and predictors. *Science*, 390: 381–385.

Torices, R., Gómez, J.M., & Pannell, J.R. (2018) Kin discrimination allows plants to modify investment towards pollinator attraction. *Nature Communications*, 9: 2018.

Waldman, B. (1988). Mechanisms of kin recognition. *Journal of Theoretical Biology*, 128: 159–185.

Wang, Y.X., Murdock, M., Lai, S.W.T., Steele, D.B., & Yoder, J.I. (2020). Kin recognition in the parasitic plant *Triphysaria versicolor* is mediated through root exudates. *Frontiers in Plant Science*, 11: 560682.

Wu, A. (2021). Transgenerational effects of kin recognition in plants: soil conditioning by an invasive plant. Master dissertation, McMaster University.

Xia, X.X., Yan, S., Wang, P., & Kong, C.H. (2025). A Meta-Analysis of Response Strategies and Interfering Factors of Kin Recognition in Plants. *Plants*, 14: 683.

Yang, X.F., Li, L.L., Xu, Y., & Kong, C.H. (2018). Kin recognition in rice (*Oryza sativa*) lines. *New Phytologist*, 220: 567–578.

Yamawo, A., Sato, M., & Mukai, H. (2017). Experimental evidence for benefit of self-discrimination in roots of a clonal plant. *AoB Plants*, 9: plx049.

Zhang, Z., Zhou, F., Pan, X., van Kleunen, M., Liu, M., & Li, B. (2019). Evolution of increased intraspecific competitive ability following introduction: the importance of relatedness among genotypes. *Journal of Ecology*, 107: 387–395.

Zhang, Z., Liu, Y., Hardrath, A., Jin H., & van Kleunen, M. (2022). Increases in multiple resources promote competitive ability of naturalized non-native plants. *Communication Biology*, 5: 1150.

Zhao, Y.Z., Liu, M.C., Feng, Y.L., Wang, D., Feng, W.W., Clay, K., ... & Kong, D.L., (2020). Release from below- and aboveground natural enemies contributes to invasion success of a temperate invader. *Plant and Soil*, 452: 19–28.

Zheng, Y.L., Burns, J.H., Wang, R.F., Yang, A.D., & Feng, Y.L. (2021). Identity recognition and the invasion of exotic plant. *Flora*, 280: 151828.

Zheng, Y.L., Feng, Y.L., Zhang, L.K., Callaway, R.M., Valiente-Banuet, A., Luo, D.Q., ... & Silva-Pereyra, C. (2015). Integrating novel chemical weapons and evolutionarily increased competitive ability in success of a tropical invader. *New Phytologist*, 205: 1350–1359.

Table 1: A systematic assessment of evidence for kin recognition in invasive plant species.

Reference	Plant invader	Life form	Evidence for kin recognition in invasive plant species
Li & Xu, 2026	*Alternanthera philoxeroides*	Herb	Under kin groups, the invasive species gained a growth advantage, whereas the native *A. sessilis* was disadvantaged.
Murphy et al. 2022	*Alliaria petiolata*	Herb	The invasive rosette-forming species *A. petiolata* increases petiole elongation and specific leaf area when growing with siblings, a phenotypic plasticity that reduces mutual shading and represents cooperative behavior
Zheng et al. 2021	*Eupatorium adenophorum*	Herb	Under high-density conditions, the invasive *E. adenophorum* exhibited stronger kin recognition compared to its native congeners (*E. fortunei* and *E. lindleyanum*).
Wu et al. 2021	*Potentilla recta*	Herb	Consistent with the finding that plants grew better with kin under low-water conditions, kin-conditioned soil also enhanced plant survival and growth under drought conditions.
Lee et al. 2021	*Taraxacum officinale*	Herb	While kinship effects on plant performance varied among populations in both invasive *T. officinale* and native *T. platycarpum*, populations originating from same site exhibited convergent kin recognition abilities.
Zhang et al. 2019	*Alternanthera philoxeroides*	Herb	While introduced genotypes of A. philoxeroides produced more branches when competing with kin versus non-kin, its native genotypes exhibited the opposite response.
Yamawo et al. 2017	*Kalanchoë daigremontiana*	Sub-shrub	Plants produced a higher number of clonal plantlets when growing with kin competitors versus non-kin competitors.
Abd El-Gawad et al. 2017	*Xanthium italicum*	Herb	Root rather than shoot biomass and competition decreased in plants grown with kin compared to those grown with non-kin.

Figure

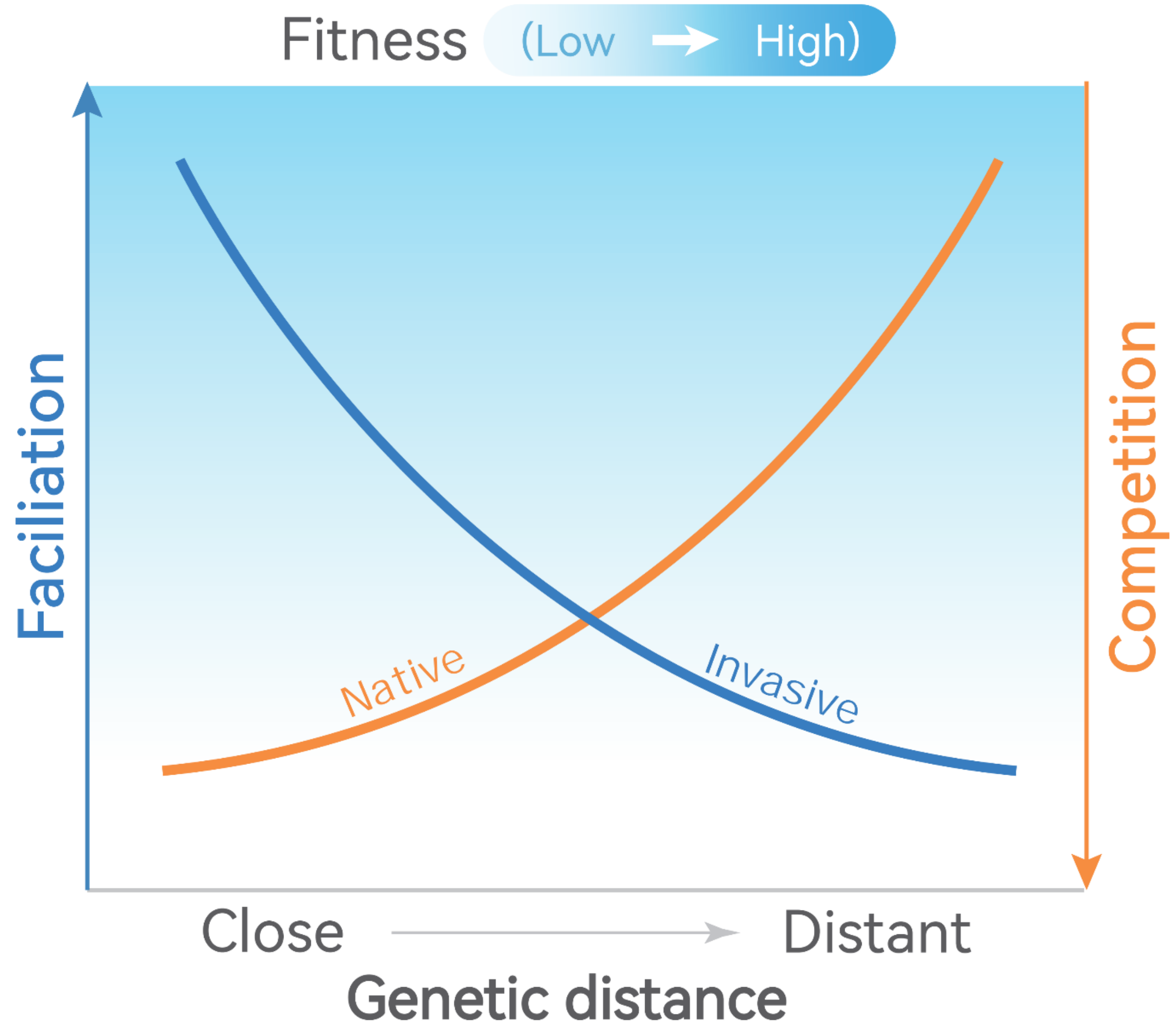

Figure 1 Conceptual illustration of effect of kin recognition on native and non-native plants. In invasive non-native plants (blue curve), a smaller genetic distance (i.e., closer relatedness) among individuals results in greater facilitation and reduced competition, thereby enhancing population-level fitness (indicated by a dark blue background). In contrast, among native plants (orange curve), a smaller genetic distance leads to stronger competition and reduced facilitation, consequently decreasing population-level fitness (indicated by a light blue background).

Supporting information

A systematic literature search for evidence of kin recognition in non-native plant species

The rising interest in kin recognition facilitating invasions has produced a growing body of literature that can enhance our understanding of the efficacy of its effectiveness as a mechanism underlying species invasiveness and guide future research. To synthesize this evidence, on 5th August, 2025, we performed a systematic literature search on the Web of Science Core Collection (https://www.webofscience.com) and Scopus (https://www.scopus.com) using the relevant keyword string as: TS(("identity recognition" OR "neighbour recognition" OR "kin recognition" OR "kin selection" OR "kin discrimination") AND (invasi* OR invader OR nonnative OR non-native OR exotic OR allochthonous OR alien OR non-indigenous OR nonindigenous OR introduced OR naturalised OR naturalized OR bioinvasi* OR weed OR "biological invasion")). The search retrieved 488 and 316 articles from Web of Science and Scopus respectively, which resulted in 605 unique studies after removal of duplicates. Of the resultant studies, we only considered experiments (1) investigating the evidence of kin recognition among invasive plants, (2) report a metric of plant performance (especially related to plant fitness and competitive ability) in both the treatment (i.e., kin group) and control (non-kin group). The screening process identified five studies that explicitly tested kin-recognition in invasive plants. In addition, three relevant studies known to authors were included, resulting in a total of eight studies. Overall, all the eight studies provided support for the existence of kin recognition in invasive plants.