Acer L. (*Acer campestre* L., *Acer platanoides* L., *Acer pseudoplatanus* L.)

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Propagation

Seed propagation

The fruits of *Acer* species, known as samaras, ripen in the mid-autumn (October), when they turn brown, indicating that they are ready for collection (Bacchetta, 2006; Navarro Cerrillo and Herrero Sierra, 2012). Fruit production varies significantly between years. Although most seeds fall easily, some can remain on the tree until the next reproductive season (Bonner and Karrfalt, 2008; Navarro Cerrillo and Herrero Sierra, 2012). Fruits are usually collected manually, using methods such as raking, sweeping, specialized vacuum cleaners, or by shaking or cutting branches (Božič et al., 2021). After collection, fruits of *Acer* with orthodox seeds (see below) should be dried on a nonhumidity absorbing surface, such as wood, in a well-ventilated place, with regular turning to ensure uniform drying (Burdekin and Rowe, 1982). Removing the wings from the samaras with machines, like bending-type devices, is uncommon as it can reduce the fruit quality (Gordon, 1992; Piotto and Di Noi, 2003; Navarro Cerrillo and Herrero Sierra, 2012).

The orthodox seeds of *A. campestre* and *A. platanoides* remain viable up to 4 years, though viability gradually decreases, when properly stored, with a moisture content between 10% and 15% and temperatures $<0°C$ (down to $-10°C$) (Burdekin and Rowe, 1982; Gordon, 1992; Navarro Cerrillo and Herrero Sierra, 2012). The seeds often have endogenous dormancy, requiring a period of cold stratification. *A. campestre* seeds show high dormancy heterogeneity and germination can be done in different ways (Navarro Cerrillo and Herrero Sierra, 2012). The seeds may be sown in autumn, immediately after harvest, or dormancy can be broken within 90 days by soaking in water at 40°C for 3 days (Navarro Cerrillo and Herrero Sierra, 2012). If sown in spring, the seeds need either 3–8 weeks of warm stratification followed by 12–24 weeks of cold stratification or, simply 13 weeks of cold stratification (Piotto and Di Noi, 2003). *A. platanoides* seeds are deeply dormant at maturity, and cold stratification for 13 weeks at 3–4°C is needed to release dormancy and achieve high germination rates (Pawlowski and Szczotka, 1997). In both species, seeds must be monitored during stratification and sown as soon as they begin to swell as they easily germinate at low temperatures (3–5°C) (Piotto and Di Noi, 2003). Seed size and viability in *A. platanoides* are greater in populations from colder, wetter environments compared with those from warmer, drier areas (Carón et al., 2014).

Unlike *A. campestre and A. platanoides*, *A. pseudoplatanus* seeds are recalcitrant, and desiccation or freezing hinders their vitality (Dickie et al., 1991; Pukacki and Juszczyk, 2015). They can germinate within a range of 3–20°C (Tylkowski, 1989). Generally, warming and drought reduce germination (Carón, 2014). For short-term storage, the seeds of *A. pseudoplatanus* should be stratified at −3°C and those that have started germinating can be stored at 3°C for up to 12 months. For optimal storage, the seeds should be kept until the following spring at a temperature of −3 to +5°C with high humidity (Gosling, 2007). Gibberellic acid enhances germination of *A. pseudoplatanus* seeds (Stejskalová et al., 2015), which can germinate during cold stratification after 42 days (Stejskalová et al., 2014). The highest germination rates occur with autumn seeding (Yücesan and Bayram, 2021). For spring seeding, it is recommended to stratify seeds at 0–5°C for 3–12 weeks, with a humidity of 44%–58% (Iliev et al., 2022). The characteristic of seed lots of the three *Acer* species are shown in Table 11.2.

Vegetative propagation

Vegetative propagation of *A. campestre* is uncommon due to the difficulty and the poor vigor of resulting plants (Navarro Cerrillo and Herrero Sierra, 2012). If used, hardwood or semihardwood cuttings, 20–25 cm long, have the lower 10 cm buried in a loose substrate, typically a 2:1 mixture of peat: perlite (Navarro Cerrillo and Herrero Sierra, 2012; Piotto and Di Noi, 2003). Rooting may be enhanced by applying hormone treatments, such as 8000 mg/L of indole-3-butyric acid (IBA), and the cuttings should be placed on rooting tables with basal heating (18–20°C) and misting (Navarro Cerrillo and Herrero Sierra, 2012).

Although *A. platanoides* can be easily propagated by seeds, vegetative propagation is preferred for cultivars, especially in urban areas, to ensure consistent phenotypic traits (Tomov, 2007). As cuttings root poorly, grafting onto seedling rootstock is more commonly used (Iliev and Tomov, 2017). Treatments such as shoot etiolation, basal banding with black tape, and applying 0.8% IBA powder can promote rooting (Tomov, 2007).

A. pseudoplatanus plants propagated from cuttings outperform those grown from seed in the early years of growth (Iliev et al., 2022; Strimbu and Nicolescu, 2023). Softwood or semihardwood shoots should be collected from spring to mid-summer (Hartmann and Kester, 2002; Spethmann, 2007). As with *A. platanoides,* auxin also stimulates rooting in *A. pseudoplatanus* cuttings (Hartmann and Kester, 2002). Cuttings should be 28–35 cm in length. Rooting *A. pseudoplatanus* is difficult but can be improved by pruning and shading donor plants in the previous season before collecting cuttings (Maynard et al., 1996). Applying fungicide treatments to prevent bark damage, a common issue for *A. pseudoplatanus*, is also recommended. Suitable fungicides include copper-based compounds, dithiocarbamates, triazoles, dinitrophenols, and phthalimides.

Table 11.2 Characteristics of seed lots of *Acer campestre, Acer platanoides,* and *Acer pseudoplatanus.*

Species	Purity (%)	No. seeds/kg	Germination capacity (%)
Acer campestre	92	8,600–25,000 (16,800)	40–80 (60)
Acer platanoides	86	2,800–10,300 (6550)	40–70 (55)
Acer pseudoplatanus	90	5400–15,800 (10,600)	40

Mean values in brackets.
Božič et al. (2021); Burdekin and Rowe (1982); Piotto and Di Noi (2003).

A substrate of peat or a peat-perlite mix is recommended for rooting cuttings (Hartmann and Kester, 2002). While *A. pseudoplatanus* forms arbuscular mycorrhizae (Rusterholz et al., 2020), the specific mycorrhizal type is not critical for root development in temperate regions (Kubisch et al., 2015). However, intensive activities in stands established from vegetative material should be avoided in the first few years to preserve the diversity of mycorrhizal fungi in the roots (Heklau et al., 2023).

Seedling cultivation

Container plants

Because nursery germination is often low (around 14%), germination can be delayed, and seedlings tolerate transplanting, it is recommended to use seedbeds (Navarro Cerrillo and Herrero Sierra, 2012). The same seedbed can be used for two growing seasons, and the seedlings can be transplanted once the two embryonic leaves are fully developed and perpendicular to the stem, just before the true leaves emerge (Navarro Cerrillo and Herrero Sierra, 2012). As container plants, the seedlings need to be transplanted into 300–400 cm^3 containers, in which plants can grow to 30–40 cm tall with a well-formed root system. In some cases, especially for restoration and landscaping use, containers with larger volumes (<3500 cm^3) can be used to obtain larger plants (40–60 cm) (Navarro Cerrillo and Herrero Sierra, 2012). Periodic treatments with broad-spectrum fungicides and soil insecticides are needed to prevent nematodes (Navarro Cerrillo and Herrero Sierra, 2012).

A. campestre is considered a slow-growing species, so maximum growth is obtained by longer growing cycles that result in compact plants, but not shorter than 30 cm. The container substrate can be various mixtures, between a minimum of 75% common material (peat moss, peat hummus, or coconut fiber) and a maximum 25% of an inorganic material (perlite, vermiculite, or sand). As there is no specific knowledge about fertilization composition and dosage, slow-release fertilizers are commonly used, for example, 18-11-10 NPK over 8–9 months with 2 g/L substrate or 14-8-15 NPK over 8–9 months with 2.5 g/L substrate (Navarro Cerrillo and Herrero Sierra, 2012). For a shorter cultivation period, an alternative is fertilized peat (with base fertilizer 16-8-16 NPK and pH correction), but control and possible adjustments need to be considered (Navarro Cerrillo and Herrero Sierra, 2012). Inoculation with arbuscular mycorrhizae fungi in the nursery could increase the survival rate and the growth after transplanting (Corsini et al., 2022).

Bare root plants

A. pseudoplatanus seeds cannot be stored for extended periods, so it's best to sow them in the spring or autumn at the beginning of the cultivation period. The growth of *A. pseudoplatanus* is hindered in dry winters; the weather conditions in July and October of the previous year and March of the current year significantly impact its radial growth (Vacek et al., 2017). In areas where it behaves as an invasive species, *A. pseudoplatanus* demonstrates better growth due to its adaptability to light conditions and phenotypic plasticity (Shouman et al., 2017). In addition, climate warming contributes to the regeneration of *A. pseudoplatanus* (Carón et al., 2015).

Liming low pH soils increases the growth of *A. pseudoplatanus* (Balcar et al., 2011). Intensive irrigation increases the mass of fine roots but also results in a reduction in the root:shoot dry-weight ratio compared with low irrigation (Hipps et al., 1996). Avoiding graywater irrigation is recommended as *A. pseudoplatanus* is sensitive to high salinity (Gräf et al., 2022). *A. pseudoplatanus* seedlings face attacks from various harmful organisms, including *Rhytisma acerinum, Nectria cinnabarina, Eutypella parasitica, Verticillium dahliae, Verticillium albo-atrum, Phytophthora* spp., and chewing insects (Sinclair and Lyon, 2005). Copper fungicides and triazoles are effective against most of these pathogens, while phenylamides (such as metalaxyl, benalaxyl, cymoxanil) are recommended against *Phytophthora* spp. Neonicotinoids or bioinsecticides are used against the insects damaging the leaves.

Recommended stock type for *A. pseudoplatanus* is 1 + 1 seedlings, with a height of 25–50 cm (Evans 1984). Regarding *A. campestre*, Navarro Cerrillo and Herrero Sierra (2012) indicated that it can be cultivated as 1 + 2 bare root stock with plants reaching a height of 80–100 cm. Among the provenances in Western Europe, no differences in growth and tree form have been found (Whittet et al., 2021). In large trees for urban forestry and ornamental purposes, there is no optimal period for pruning *A. pseudoplatanus* (Fini et al., 2013) (Fig. 11.2).

Field establishment

A. campestre is naturally present across Europe, except in the northern parts. It does not form pure stands and it is commonly a subdominant species in numerous plant communities (Chybicki et al., 2014). The main limitations for seedling establishment are the low viability of the seeds, insufficient growth, and sensitivity of the seedlings in the first 3 years to stressors, especially drought. Summer watering and mulching with straw can partially overcome drought (Navarro Cerrillo and Herrero Sierra, 2012). Planting seedlings is the recommended revegetation method. If direct seeding is chosen, it should be performed in autumn (Navarro Cerrillo and Herrero Sierra, 2012). If planting is preferred, using larger seedlings, especially those cultivated in large containers (>1000 mL) increases

Figure 11.2 *Acer pseudoplatanus* 1 + 0 container seedlings (left) and bare root seedlings (right). *(Vladan Ivetić.)*

establishment rates. In sites with large herbivores, seedlings must be protected by fencing or by using tall tree shelters (Navarro Cerrillo and Herrero Sierra, 2012).

A. campestre seedlings can be planted in groups at favorable locations to increase survival rates. For instance, high planting densities (200 plants/ha) are recommended on lower parts of slopes, where water availability and soil depth are greater. This density should be reduced to 100 plants/ha on the upper part of slopes, promoting more complex vegetation with moderate competition and healthy plants with good branching and vigor (Navarro Cerrillo and Herrero Sierra, 2012).

We recommend digging large, deep holes (40 × 40 × 60 cm) as a soil preparation method with removal of weeds. Although *A. campestre* is tolerant of poor soil conditions, soils prone to waterlogging should be avoided (Banks et al., 2019; Navarro Cerrillo and Herrero Sierra, 2012).

A. platanoides is generally tolerant to prolonged periods of dry and very wet soil, but this can vary among cultivars, which is important to know during the selection of reproductive material (Banks et al., 2019).

The main factors that limit the establishment of *A. pseudoplatanus* are closed-canopy stands, competition from weeds, and mammal damage (Hein et al., 2009). *A. pseudoplatanus* thrives on different types of soil, and with its developed roots, it can rehabilitate places exposed to erosion (Caudullo and de Rigo, 2016). Seedlings develop poorly in contaminated soils, but there are several tolerant genotypes that show better health (Turner and Dickinson, 1993).

Climate change threatens the development of *A. pseudoplatanus* seedlings (Carón et al., 2015). Seeds germinate best in autumn (Yücesan and Bayram, 2021), and seedlings generally have high frost resistance (Piovesan et al., 2005). Therefore, regeneration in autumn is recommended. Waterlogged soils must be avoided and planting should be concentrated on well drained soils with higher clay and nitrogen content (Jensen et al., 2008). In mixed plantations of *A. pseudoplatanus* and *Fagus sylvatica*, it is crucial to increase the density of *A. pseudoplatanus,* as *F. sylvatica* absorbs N faster and is more competitive (Li et al., 2015). To protect seedlings against harsh weather conditions, managing canopy openings is important to prevent microclimate disturbances in the stands. Manual removal of weeds should be favored over herbicides to avoid environmental issues.

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