As a result of the intensification of adverse and extreme climatic events, there is a growing interest in the implementation of agrobiodiversity strategies and in alternative crops, characterized by low-input requirements and high tolerance to abiotic stress. Moreover, in developed countries, new and niche products often have good markets. One such crop is a wild asparagus species (*Asparagus acutifolius* L.), a perennial herbaceous plant with spears that have been used in the Mediterranean area as a delicacy food since ancient times (Aliotta et al., 2004). These spears are still appreciated and sold regularly in niche markets (Di Maro et al., 2013; Ferrara et al., 2011; Pieroni et al., 2005). This species is widely distributed in semidyman environments and as understory vegetation (Conversa and Elia, 2009), showing high phenotypical plasticity with its ability to grow in both sunny or semishaded areas and also under adverse edaphic conditions. In particular, as a result of its adaptability to different light conditions, the species has recently been proposed as an understory crop for agroforestry systems (Dupraz et al., 2018; Paris et al., 2019). Nonetheless, this wild asparagus has not been cultivated until recently, and the market is sustained mostly by harvesting spears from naturally occurring plants, so the price can be four times greater than that of the spears of the cultivated species *Asparagus officinalis* L. (Benincasa et al., 2007; Rosati, 2001). The high price makes it an attractive potential new crop, even though its yield is relatively less compared with the commercial species (Benincasa et al., 2007; Rosati et al., 2005). Being a relatively undemanding plant, this wild asparagus could be a suitable crop for low-input agricultural systems. In fact, considering that there are no selected cultivars and the plant is wild, the crop is essentially free of pests and diseases, and is suitable for organic farming. However, although some previous research investigated seed germination and transplant management (Conversa and Elia, 2009; Rosati and Falavigna, 2000) and cultivation techniques for this wild asparagus, it is not known how the species reacts to variations in temperature and water stress. In addition, the species is known to have ecophysiologic plasticity, however there is no literature on this subject. This work aimed at assessing the photosynthetic characteristics of this wild species, grown under full light (FL) and partial (i.e., about 40%) light (PL) conditions, and evaluating its ecophysiologic response to drought and temperature stress. The photosynthetic response to light of spears and of new cladodes (NC; current year) and old cladodes (OC; previous year) was measured using an infrared gas analyzer coupled with a climatized cuvette chamber. Cladodes net photosynthesis at high irradiance was also measured at varying air temperatures and decreasing soil water availability. Results indicate that developing spears were photosynthetically active with no difference between FL and PL treatments. Photosynthetic rates did not differ between NCs and OCs and were greater for FL cladodes, except at low irradiance. Well-watered plants were photosynthetically active from 0 to 45 °C, with a maximum photosynthetic rate of up to 9 μmol·m⁻²·s⁻¹ at 30 °C and a decrease of about 60% at 45 °C. The species also demonstrated high tolerance to drought, with positive net photosynthesis even at predawn leaf water potential values of –2.4 MPa. Showing great ecophysiologic plasticity, this wild asparagus could be an interesting species in areas were conventional crops are not profitable economically, or as an intercrop in agroforestry systems.
Photosynthetic activity of different organs. During Spring 2015, the photosynthetic response to varying PAR levels of the FL and PL plants was measured on different plant organs: 1) spear tips, about the top 30 mm; 2) spear trunks (spear subapical portions), measured at $\approx 100$ mm from the tip; 3) new fully developed cladodes (NCs) grown during the vegetation period of 2015; and 4) old cladodes (OCs) of shoots grown the previous year (vegetation period, 2014). Measurements were carried out using a portable infrared gas analyzer (model 6400; LI-COR, Lincoln, NE) equipped with CO$_2$ and light control modules. The measurements on NCs and OCs were performed by sealing small branches with $\approx 40$ to 70 cladodes into a climate-controlled leaf chamber (30 $\times$ 20 mm). Two branches (one for OCs and one for NCs) per plant on each of the 10 plants per light treatment were measured. The total lateral area of the cladodes for each measurement was estimated by measuring length and diameter of 10 cladodes for each branch, approximating the cladode shape to a cylinder. The average lateral area obtained from the 10 cladodes was multiplied by the total number of cladodes sealed into the chamber. Because it is assumed that only one side of the cladode is sunlit, the photosynthesis values referred to half the lateral area, in accordance with the methodology used for Asparagus officinalis (Guo et al., 2002). Spear photosynthesis was measured by enclosing the spear tip or trunk into the leaf chamber. The lateral area was calculated by approximating the spear to a cylinder, and photosynthesis values referred to half the lateral area, assuming only half was sunlit. One spear tip and trunk per plant on each of the 10 plants per light treatment (i.e., FL and PL) were measured.

For both spear and cladode light response curves, air temperature in the leaf chamber was set at 20 $^\circ$C and relative air humidity at $\approx 50\%$. PAR intensity steps were as follows: 0, 20, 50, 100, 300, 500, 700, 1000, 1300, 1500, and 2000 $\mu$mol·m$^{-2}$·s$^{-1}$, and at each step the measurements were taken when steady-state assimilation was reached.

The morphology of the cladodes grown under the different light conditions (i.e., FL and PL) was evaluated by measuring cladode diameter and length, and calculating their lateral area, volume, and the lateral area-to-volume ratio for all the samples taken for gas exchange measurements ($n = 400$).

Photosynthetic response to drought and temperature, and water potential. In addition to the light response curves, the photosynthetic response of NCs to varying temperature was evaluated on well-watered plants during Summer 2015 and the following winter at a constant PAR intensity of 1500 $\mu$mol·m$^{-2}$·s$^{-1}$ [net CO$_2$ assimilation response ($A_{\text{nc}}$)] on one branch (with the same characteristics as for the other measurements) per plant on five plants per light treatment at intervals of 5 $^\circ$C, from 20 to 45 $^\circ$C during Summer 2015, and from 0 to 15 $^\circ$C during the following winter.

In an additional experiment, during Summer 2015, the combined effects of drought and high temperature on cladode photosynthesis was evaluated by measuring the photosynthetic response to increasing temperature also at progressively reduced soil water availability. To impose drought stress, five potted plants per light treatment were not irrigated for 6 consecutive days. The level of drought was assessed by recording both the gravimetric soil water content ($\theta$) of each pot and the predawn leaf water potential ($\Psi_L$) on days 0, 2, 4, 5, and 6 of the drought cycle. At the beginning of the experiment, the plants were overwatered, drained overnight, and pot weight was recorded, assuming the soil was at field capacity. The water-holding capacity of the soil was measured by using the thermogravimetric method (Pansu and Gautheroy, 2007) on five pots without plants. From these measurements, we determined that field capacity corresponded to a $\theta$ value of 0.33 kg·kg$^{-1}$. During the drying process, all pots were weighed in the early morning, and the $\theta$ values were calculated based on the weight difference compared with field capacity.

$\Psi_L$ was measured on three small branches (like those sampled for gas exchange measurement) per plant, on each of the five plants per light treatment, using a Scholander pressure chamber (Scholander et al., 1965).

The photosynthetic response to increasing temperature was assessed at field capacity (in the dark, $\Psi_L = -0.9$ MPa, day 0), mild water stress ($\Psi_L = -1.4$ MPa, day 4), and severe water stress ($\Psi_L = -2.4$ MPa, day 6), sampling three branches per plant on each of the five plants per light treatment. The increasing temperature treatments were interrupted whenever net photosynthesis approached zero.

Data analysis. Data from different plant organs (spear tips, spear trunks, NCs, OCs) and light treatments (FL, PL) and from NCs at different temperatures and soil water availability were subjected to analysis of variance according to a completely randomized design, with pots as replicates. Means were compared by least significant difference at the 0.05 confidence level. The R statistical environment (R Development Core Team, 2014) was used to perform the analysis.

Results

Photosynthesis and morphology of the different organs. Light treatments had no significant effects on spear gas exchange (data not shown), therefore the data were pooled for the two treatments. The spear trunk (subapical portion of the spear) had negative net photosynthesis (An), but reached values close to zero when An saturated at about 1500 $\mu$mol·m$^{-2}$·s$^{-1}$ (Fig. 1A). The spear tips also saturated at similar irradiance levels, but had much more negative photosynthetic values at any PAR tested, resulting from a 3-fold greater respiration rate in the dark as shown by the An value at zero PAR. However, the spear tips photosynthetic contribution was much greater in absolute terms, as shown by the much greater values of gross photosynthesis (Ag) at any PAR level (Fig. 1B).

NCs and OCs within the same light treatment had comparable An (data not shown), hence data were pooled. Cladode An increased with increasing PAR, never reaching saturation, in both light treatments (Fig. 2A). The FL treatment had greater An at PAR values greater than 50 $\mu$mol·m$^{-2}$·s$^{-1}$, but An tended to be lower below this PAR value, although not significantly (Fig. 2B). The light compensation point was reached at PAR values of 18.5 $\pm$ 4.0 and 13.3 $\pm$ 3.1 $\mu$mol·m$^{-2}$·s$^{-1}$ for FL and PL, respectively. The FL plants had shorter and thicker cladodes with a smaller lateral area, and a smaller lateral area-to-volume ratio, compared with the PL plants (Table 1).

Photosynthetic response to drought and temperature. On day 0 of the drought experiment, pots were at field capacity ($\theta = 0.33$ kg·kg$^{-1}$) and the plants’ $\Psi_L$ was $-0.9$ MPa.

![Fig. 1.](image-url) (A) Net (An) and (B) gross (Ag) CO$_2$ assimilation response to photosynthetically active radiation (PAR) of well-watered Asparagus acutifolius spear tips and spear trunks measured at 20 $^\circ$C (air temperature). Data from the full light and partial light treatments were pooled. Data represent mean and SE (bars) of 20 measurements.
As θ decreased, Ψₗ also dropped, reaching –2.4 MPa on day 6, when θ was 0.10 kg·kg⁻¹. With the soil at field capacity and with an incident PAR of 1500 μmol·m⁻²·s⁻¹, although the difference was not significant at any given temperature, An₁₅₀₀ was constantly greater for FL cladodes, except at extreme temperatures (Fig. 4A). The greatest photosynthetic rate occurred at an air temperature of 30 °C for both treatments, whereas at both higher and lower temperature, the difference between FL and PL declined dramatically, reaching zero at 0 and 45 °C. With increasing drought intensity, the difference in An₁₅₀₀ between the FL and PL treatments became negligible at any temperature, and data were pooled (Fig. 4B). An₁₅₀₀ decreased with temperature at any drought (i.e., Ψₗ) level and with Ψₗ at any temperature. At 30 °C, An₁₅₀₀ was reduced by 59% and 83%, respectively, with Ψₗ values of –1.4 and –2.4 MPa. When the air temperature was increased from 30 to 35 °C, An₁₅₀₀ decreased by 5% at field capacity (Ψₗ = –0.9 MPa), by 74% under mild drought (Ψₗ = –1.4 MPa), and even more strongly, becoming negative, under severe drought conditions (Ψₗ = –2.4 MPa). At 40 °C, An₁₅₀₀ decreased strongly (46%) also at field capacity, and even more drastically (93%) under mild drought conditions (Ψₗ = –1.4 MPa). At 45 °C, only well-watered plants had positive net photosynthesis, although with a reduction of 60%. As net photosynthesis decreased with both temperature and drought, the intercellular CO₂ concentration increased, both at increasing temperatures (for all drought levels) and at increasing levels of drought, except between field capacity (Ψₗ = –0.9 MPa) and intermediate water stress (Ψₗ = –1.4 MPa) at 30 and 35 °C (Fig. 5).

**Discussion**

**Photosynthetic characteristics of spears.** Although the wild asparagus species considered here is known in the Mediterranean for its edible spears, and its cultivation has been proposed and studied (Aliotta et al., 2004; Benincasa et al., 2007; Rosati et al., 2009), no information about its ecophysiology has been published. Several studies are instead available for the cultivated species (Asparagus officinalis L.). Our data indicate that, unlike the cladodes, spears growing under different light conditions did not differ in their CO₂ assimilation rates, suggesting that the rapidly growing spears do not have time to adapt to different light environments. This appears reasonable because the spears grow at a fast rate and measurements were taken at the tip (spear tip) and subapical portions (spear trunk), which were exposed to the different light treatments for only a few hours (spear tips) or days (spear trunks). The most interesting result regarding the spears’ gas exchange is probably that they are photosynthetically active at an early stage (Fig. 1), hence most likely contributing to their own trophism. This could help reduce the depletion of sugars stored in the fleshly roots during the springtime, as found in Asparagus officinalis (Dowton and Torokfalvy, 1975).

In our study, at high irradiance, the spear tips reached gross photosynthetic (Ag) values per unit area of about half the value recorded for the cladodes. Nonetheless, spear net assimilation was always negative as a result of high respiration, which is clearly connected to intense growth and metabolism of the young tissues (McCree, 1974). Also interesting is the fact that the subapical portion of the spear had less-negative net photosynthetic rates (Fig. 1A), despite having lower gross photosynthetic contributions (Fig. 1B), which is explained by the lower respiration, compared with the spear tips (Fig. 1A). In fact, in cultivated asparagus, high metabolism of the tip is proved by the rapid reduction of the sugars in the upward direction, from the stalk to the tip; below the tip there is the so-called elongation zone, where the cells are expanded and thickened and metabolism is reduced (Culpepper and Moon, 1939). In addition, the subapical zone is characterized by the rapid addition of cellulose and other structural materials, which may interfere with the photosynthetic activity (Edwards and Walker, 1983), explaining the lower contribution in this zone in terms of gross photosynthesis.

**Photosynthetic characteristics of cladodes.** Although photosynthesis of tips and trunks saturated at high irradiance (i.e., 1500 μmol·m⁻²·s⁻¹) (Fig. 1), as expected for a flat photosynthetic surface, the cladodes’ light–response curve was not asymptotic. This is probably because the cladodes’ net photosynthesis was measured on small branches with 40 to 70 cladodes, oriented in all directions, rather than measuring a flat surface such as a broad leaf. Therefore, the cladodes captured the direct light, the diffuse light, and the light reflected by the cuvette walls, as described for conifers (Carter and Smith, 1985). Also, the direct light (i.e., the majority under sunny conditions) was not perpendicular to most cladodes, making them unlikely to reach saturation (Sinclair et al., 1976). Unlike the cultivated species, the ferns of this wild asparagus are perennial, and the photosynthetic activity of previous and current-year ferns was comparable. This gives this species a great advantage over the cultivated asparagus, which, as a deciduous species, has no green vegetation from fall to spring and has to regrow all the canopy each year before it can be photosynthetically active. Having photosynthetically active ferns before and during the harvest of the spears, the spring storage depletion reported for the cultivated species (Haynes, 1987) should be reduced in the wild asparagus, although there is no literature available to prove this. In fact, during the winter, net C assimilation was positive down to 0 °C (Fig. 4A). Considering the Mediterranean habitat of the species, with mild winters, the plant appears to have the opportunity to produce and store reserves during the winter. The evergreen nature of the plant, combined

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**Table 1. Cladode morphologic characteristics in Asparagus acutifolius as affected by the light treatments full light (FL) and partial light (PL).**

| Treatment | Length (mm) | Radius (mm) | Lateral area (mm²) | Volume (mm³) | Lateral area/vol. (mm²·mm⁻³) |
|-----------|-------------|-------------|-------------------|-------------|-----------------------------|
| FL        | 4.26 ± 0.30 b | 0.24 ± 0.01 b | 6.44 ± 0.56 b | 0.78 ± 0.08 a | 8.26 ± 0.28 b              |
| PL        | 6.31 ± 0.38 a | 0.21 ± 0.01 a | 8.38 ± 0.64 a   | 0.90 ± 0.10 a | 9.31 ± 0.34 a              |

*Data are the means of 400 cladodes. Different letters indicate significant differences (P ≤ 0.05) between treatments.*

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**Fig. 2.** (A) Net CO₂ assimilation response (An) to photosynthetically active radiation (PAR) of Asparagus acutifolius cladodes from well-watered plants grown in full light (FL) or partial light (PL), measured at 20 °C (air temperature). Data from the new and old cladodes were pooled. Data represent mean and se: (bars) of 20 measurements. (B) Same data, but only for PAR values from 0 to 100 μmol·m⁻²·s⁻¹.
with the positive photosynthesis at low temperatures, appears to explain the plant’s natural occurrence in woodlands and shrublands (Tutin, 1980); the plant can take advantage of the light available during the winter in deciduous forests. However, the plant appears just as adapted to take advantage of full-sun conditions, even in hot Mediterranean summers. In fact, photosynthesis was greater for plants grown in full light (Fig. 2A), except at extreme temperatures (Fig. 4A). This was related to different cladode morphology. FL plants had thicker and shorter cladodes, suggesting plasticity of the plant in adapting to varying light environments. Guo et al. (2002) compared two varieties of Asparagus officinalis and found that the higher yielding variety, which also had greater photosynthesis, presented thicker cladodes. They, supported by the results of previous investigations (Bai and Kelly 1999; Faville et al., 1999), attributed the greater CO2 assimilation activity at least in part to thicker cladodes containing more mesophyll cells. Thicker leaves grown under high irradiance are known to have greater assimilation rates at high PAR values (Hills, 1986; Rosati et al., 1999, 2000). At high temperatures, however, a more abundant mesophyll per unit of photosynthetic area [i.e., lower lateral area-to-volume ratio (Table 1)] implies a greater imbalance between photosynthesis and respiration, caused by heat stress (Wahid, 2007), compared with PL cladodes, explaining why FL plants lose their advantage over PL plants at increasing temperature.

The adaptation of this wild asparagus to hot and highly illuminated environments was further shown by its ability to keep positive photosynthesis at both high temperatures, up to 45 °C, and under drought conditions (Fig. 4). Increasing the air temperature from 30 to 45 °C reduced AN1500 by only 60% (Fig. 4B), whereas in most plants, exposure to temperatures greater than 35 °C may cause irreversible injury to the photosynthetic system (Berry and Bjorkman, 1980). However, eventually, heat stress leads to photoinhibition; consequently, a reduction in primary production is to be expected (Boyer, 1982; Larcher, 1995). Also, the decline of the photosynthetic rate with increasing water stress was quite moderate and became severe (83%) only at Ψw values of –2.4 MPa (Fig. 4B), which are not tolerated by most plant species (Lammers et al., 2008). The reduction in photosynthetic rates at high temperatures and drought conditions did not appear to result from stomatal control, because the intercellular CO2 concentration always increased at both increasing temperatures and drought conditions (Fig. 5), and therefore it appeared to be the result of direct impacts on photosynthetic metabolism (Farquhar and Sharkey, 1982). The intertwined effect of heat and drought stress (Fig. 4B) suggests that irrigation may be a means to overcome or limit heat stress in high-temperature environments, whereas shade and the consequent cooling may help where irrigation is not available.

**Conclusions**

The wild asparagus species we studied appears to combine an assimilation ability comparable with that of the cultivated asparagus under optimal growing conditions, but also shows adaptability to shade, extremely low winter and high summer temperatures, and severe drought. Hence, this species shows great ecophysiological plasticity. In a present and future scenario of climate change, with higher temperatures, more frequent droughts, and a more erratic climate, this wild asparagus represents an interesting crop able to withstand temperature extremes and droughts. In addition, under such scenarios, agroforestry systems combining trees and crops are believed to have the potential to both mitigate and provide adaptation to climate change. However, tree shade usually reduces crop production. This wild asparagus has the ability to adapt to diversities and could be an evergreen species with positive photosynthesis at low temperature, thus photosynthesizing in winter when deciduous trees allow good lighting of the understory layer. In addition, tree shade reduces leaf temperatures and this might reduce high-temperature stress and enhance photosynthesis under moderate shade in the summer, when temperature—and not light—is the limiting factor. All in all, Asparagus acutifolius could be a useful perennial species in challenging environments, both as a monocrop or as the understorey layer in agroforestry systems designed for high resiliency and climate adaptation.

**Literature Cited**

Aliotta, G., S. Aceto, A. Farina, L. Gaudio, A. Rosati, M. Sica, and A. Parente. 2004. Natural history, cultivation and biodiversity assessment of asparagus. Res. Adv. Agr. Food Chem. 5:1–12.
values, metabolic profile and radical scavenging capacities of wild asparagus (Asparagus acutifolius L.). J. Food Compos. Anal. 24:326–333.
Guo, J., W.A. Jermyn, and M.H. Turnbull. 2002. Diurnal and seasonal photosynthesis in two asparagus cultivars with contrasting yield. Crop Sci. 42(2):399–405.
Haynes, R.J. 1987. Accumulation of dry matter and changes in storage carbohydrate and amino acid content in the first 2 years of asparagus growth. Scientia Hort. 32(1–2):17–23.
Hills, M.J. 1986. Photosynthetic characteristics of mesophyll cells isolated from cladophylls of Asparagus officinalis L. Planta 169(1):38–45.
Lambers, H., F.S. Chapin, III, and T.L. Pons. 2008. Plant water relations, p. 163–223. In: H. Lambers (ed.). Plant physiological ecology. Springer, New York, NY.
Larcher, W. 1995. Photosynthesis as a tool for indicating temperature stress events, p. 261–277. In: E.D. Schulze and M. M. Caldwell (ed.). Ecophysiology of photosynthesis. Springer, Berlin, Germany.
Mantovani, D., M. Veste, and D. Freese. 2014a. Black locust (Robinia pseudoacacia L.) eco-physiological and morphological adaptations to drought and their consequence on biomass production and water-use efficiency. N. Z. J. For. Sci. 44(1):1–11.
Mantovani, D., M. Veste, S. Gypser, C. Halke, L. Koning, and D. Freese. 2014b. Transpiration and biomass production of the bio-energy crop giant knotweed IGNISCUM under different water and nutrient supply. J. Hydrol. Hydro- mech. 62:316–323.
McCree, K.J. 1974. Equations for the rate of dark respiration of white clover and grain sorghum, as functions of dry weight, photosynthetic rate, and temperature. Crop Sci. 14(4):509–514.
Pansu, M. and J. Gauthreyrou. 2007. Handbook of soil analysis: Mineralogical, organic and inorganic methods. Springer, Germany.
Paris, P., F. Camilli, A. Rosati, A. Mantino, G. Mezzalira, C. Dalla Valle, A. Franca, G. Seddaiu, A. Pisanelli, M. Lauteri, A. Brunori, G.A. Re, F. Sanna, G. Ragaglini, M. Mele, V. Ferrario, and P.J. Burgess. 2019. What is the future for agroforestry in Italy? Agrofor. Syst., doi: 10.1007/s10457-019-00346-y.
Peary, R.W., R.J. Ehleringer, H. Mooney, and P.W. Rundel. 2012. Plant physiological ecology: Field methods and instrumentation. Springer, Germany.
Pieroni, A., S. Nebel, R.F. Santoro, and M. Heinrich. 2005. Food for two seasons: Culinary uses of non-cultivated local vegetables and mushrooms in a south Italian village. Intl. J. Food Sci. Nutr. 56(4):245–272.
R Development Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org/>.
Rosati, A. 2001. Un possibile futuro per l’asparago selvatico. Inf. Agrar. 7(57):89–92.
Rosati, A., S. Caporali, and A. Paoletti. 2009. Olive, asparagus and animals: an agroforestry model for temperate climate in developed countries. Proceedings of the III OLIVEBIO-TEQ (For a renovated, profitable and competitive Mediterranean olive growing sector), Sfax, Tunisia, 15–19 Dec. 2009, ISBN: 978-9938-9513-0-1, 229–233.
Rosati, A., K.R. Day, and T.M. Dejong. 2000. Distribution of leaf mass per unit area and leaf nitrogen concentration determine partitioning of leaf nitrogen within peach tree canopies. Tree Physiol. 20:271–276.
Rosati, A., G. Esparza, T.M. Dejong, and R.W. Peary. 1999. Influence of canopy light environment and nitrogen availability on leaf photosynthetic characteristics and photosynthetic nitrogen-use efficiency of field-grown nectarine trees. Tree Physiol. 19:173–180.
Rosati, A. and A. Falavigna. 2000. Germinazione dei semi di asparago selvatico. Inf. Agrar. 46(56):53–55.
Rosati, A., R. Pepe, A. Senatoro, D. Perrone, and A. Falavigna. 2005. Produttività dell’asparago selvatico. Inf. Agrar. 8(61):75–77.
Scholander, P.F., E.D. Bradstreet, E.A. Hemmingsen, and H.T. Hammel. 1965. Sap pressure in vascular plants: Negative hydrostatic pressure can be measured in plants. Science 148(3668):339–346.
Sinclair, T.R., C.E. Murphy, and K.R. Knoerr. 1976. Development and evaluation of simplified models for simulating canopy photosynthesis and transpiration. J. Appl. Ecol. 13:813–829.
Tutin, T.G. 1980. Flora europaea. Vol. 5. Cambridge University Press, Cambridge, UK.
Veste, M. and W.U. Kriebitzsch. 2013. Influence of drought stress on photosynthesis, transpiration, and growth of juvenile black locust (Robinia pseudoacacia L.). Forstarchiv 84(2):219–228.