GEOGRAPHICAL DISTRIBUTION

- Species originated in the Balkans [30]; Asia Minor [2] and Persia [10].
- Occurs naturally south of the Caspian Sea and in the southern Caucasus, and extends to Turkey, Bulgaria, Greece, Yugoslavia [22] and as far as China [9, 24].
- Introduced into Europe in classical times [30].

Area of origin of the Common walnut in Europe
(Krussmann, 1979, as amended [5])

Statistics for France:
- Area planted with Common walnut = 20,117 ha (Agreste, 2007).
- Volume of Common walnut in production forests as surveyed in 1996 (NFI): 423,153 m$^3$ (2,021,300 trees). Together with trees surveyed in other woodlands, planted rows, hedges, etc., and single trees, and in the dual-purpose walnut groves in Isère (119,000 m$^3$), the total number of trees amounts to 4.5 - 5 million [7].
- Volume of marketed timber: 100,000 m$^3$/year at the beginning of the last century; 20,000 m$^3$/year in the early 1990s [7].

CLIMATE AND TEMPERAMENT

Bioclimatic conditions
Climate is the main growth factor [5] for this species although it tolerates varied climate conditions [17].

Common Walnut:
- Prefers mild climates [30] with dry continental air [17]. Cool and humid climates encourage fungal diseases [5].
- Requires warmth during the growing season (6 months with an average temperature $\geq 10 ^\circ$C) [12, 2, 7, 25, 10, 17, 20].
- Withstands cold conditions down to $-30 ^\circ$C in winter if the temperature drops gradually [7, 25]. A sharp drop in temperature can damage or kill the trees [7].
- Fairly vulnerable to late frost (for varieties in which the buds break early) and vulnerable to early frost (below $-7 ^\circ$C [7, 10] or even $-2 ^\circ$C), especially after a mild autumn and in particular the first years of growth [12, 21].
- Requires a minimum of 180 days of growing season per annum [7].
- Requires over 700 mm/year of rainfall, well distributed throughout the year (optimally from 1000 to 1200 mm/year [25] unless there are sufficient water reserves in the ground, in which case 500 mm/year may be enough) [12, 28, 5, 7, 25, 10, 17].
- Resistant to drought thanks to its tap root: on soft ground, it can draw water from deep underground [7, 20], but the minimum rainfall during the growing period must remain above 100-150 mm [12, 18]; more drought resistant in the juvenile stage [31].
- Fairly sensitive to wind [77]: stems may break in storms or growth may lean away from frequent winds in a constant direction (e.g. mistral, etc.). Plant the trees on sites sheltered from the wind [14, 5] or plant quick-growing hedge-type vegetation to protect them [31, 13].

### Summary of bioclimatic requirements and sensitivity of the Common walnut

<table>
<thead>
<tr>
<th>Warmth Requirement</th>
<th>Cold</th>
<th>Late frosts</th>
<th>Early frosts</th>
<th>Sticky snow</th>
<th>Wind</th>
<th>Drought</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
</tbody>
</table>

### Vegetation stages
- Occurs essentially in the **sub-montane stage** up to 700-800 m [12, 16, 5, 7, 31].
- Although found on higher stages, it can be planted at up to 1000 m in the protected valleys of the Southern Alps [5, 7, 2]. Elsewhere, the timber is likely to incur frost crack above 800 m. (invisible from the outside) [5, 7].

#### Distribution of the Common walnut according to vegetation stages

![Vegetation stages diagram](chart)

- **Temperament**
  - An open-field species thriving in **full light** [5, 7, 30, 22, 10]: tolerates shade in its early years, but at the expense of growth. Light-demanding in its mature phase [5].
  - **Very sensitive to competition** from other forest species [10, 20].
  - Sensitive to sun scald at a young age [27, 7] (while the bark is smooth).
  - **Phototropic** [5, 7].
  - Exposure: favours south-west facing slopes in cool climate areas. Avoid south-facing slopes in hot climates [14, 2].

#### Climatic limits
**Temperature:**
- Annual average: at least 7° C [5].
- Absolute minimum: -30° C [5, 7], but varies with the origin of the tree.
- Absolute maximum: probably high (the species has withstood heatwaves such as in 2003 in France, but this can depend on the origin of the tree [Becquey J., pers. comm., 2012]).

#### SOILS
Occurs on rock and a variety of geological formations [5].

#### Water and drainage
**Water supply:**
- **Water demanding** species, thrives in humid to moderately humid conditions [30], requiring soils with plentiful water reserves [19, 8, 14, 13] for good growth. Moderate potential on moderately humid sites [19].

**Waterlogging:**
- The species is **very sensitive to waterlogging**, even temporary, to at least 80 cm in depth [14, 5, 7, 17]. Soils to avoid are therefore wet soils and areas with a permanent water table close to the surface (ideally the water table should be deeper than 1.5 m [17]).
### Drainage and excess water

<table>
<thead>
<tr>
<th>Natural drainage</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>h</th>
<th>i</th>
<th>e</th>
<th>f</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>excessive</td>
<td>good</td>
<td>moderate</td>
<td>imperfect</td>
<td>poor</td>
<td>very poor</td>
<td>partial</td>
<td>virtually non-existent</td>
<td>non-existent</td>
<td></td>
</tr>
<tr>
<td>temporary water table</td>
<td>-</td>
<td>-</td>
<td>no water table</td>
<td>-</td>
<td>60-125 cm</td>
<td>60-80 cm</td>
<td>0-30 cm</td>
<td>20-50 cm</td>
<td>0-30 cm</td>
</tr>
<tr>
<td>permanent water table</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(From the Species Ecology file, Ministry of the Wallon Region, 1991, amended [27])

### Topographic situations:
- **Favourable:** alluvial plains (the most favourable areas when stagnant water is absent), small enclosed side valleys [17], slopes with a good water supply (deep soils, especially in concave areas [7]), depressions on plateaus.
- **Unfavourable:** frost pockets and valley bottoms with stagnant air (narrow valleys, basins) [14, 5, 7].

#### Favourable topographic situations for the Common walnut in terms of water supply

(Involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)

![Diagram showing favourable, tolerated, and unfavourable topographic situations](Diagram)

### Texture and materials
- The texture of the surface horizons should be balanced: clay-sand loam or sand-clay loam [11, 30]. Waterlogging may occur in a rainy climate on clayey soils, especially on the surface. The ideal soil composition is as follows: clay = 18-25%, loam = 30-50% and sand = 30-50% [28, 18, 25]. The proportion of clay may be greater at depth. A sandy texture is appropriate if there is a plentiful water supply (water table present) [11, 7].
- **Surface** horizons must be friable, well structured and porous, lumpy or sub-angular polyhedral [11].
- The soil must be at least 80 cm thick with good water retention [12, 16, 5, 11, 7, 10, 20].
- Grows on stony soils if rooting is possible at 80 cm. It can be even found on screes [20]. To ensure good productivity, particularly in dry climates, the coarse component of the surface horizons should be less than 10% [11].

#### Textures favouring growth of the Common walnut

(Involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

| very sandy | coarse | loamy | intermediate | clayey | very clayey |
| S, SL | SA, LS | LmS, Lm, LI, LIS | LSA, LSA, LA, AL | A, AS | ALo |

**Favourable:**
- Thick brown lime or calcium soils at the bottom of slopes (colluvium) [27, 19].
- Neutral or slightly acidic, deep, loamy or predominantly sandy valley or plain soils (alluvial) [11, 13].

**Unfavourable:**
- Compact or wet clay soils (pseudo gley) [12, 21, 5, 11, 7, 32, 25, 10]; very loamy soil crusts [7]; thin or highly filtering soils [2].

### Nutrients

#### Nutritive elements:
- Should be planted on rich soils for optimum production [14, 7, 2], but adapts to moderately fertile soils if the water supply is sufficient [9]. Optimum growth on rich soil with pH = 6.5 to 7.5 [12, 11, 7, 25, 30, 10], but tolerates a pH of 5.5 to 8.5 [2]; avoid poorer soils with pH < 5.5 [5, 7].
- Optimum humus: calcium to mesotrophic mull [30].
- The growth of the Common walnut is closely linked to the C/N ratio and to a lesser extent to the P₂O₅ content; for good growth, mineral nutrients must be readily available with sufficient organic matter and phosphoric anhydride: 1.5-2% organic matter [12, 11, 25].
- On poor soils where growth is slow, the timber is highly coloured and veined and thus suited to top-of-the-range veneer and high-quality cabinet making (unique furniture pieces); fast-growing trees on rich soils usually produce light-coloured timber suitable for cladding and industrial cabinet making (mass production) [7].
- Sensitive to soil salinity (electrical conductivity < 1.5 dS/m) [12, 21].

Autecology of Walnut species - p. 34
Lime in fine soil:
- Grows on fertile alkaline soils [30, 26], but avoid pH > 7.5-8.5 with excessive active lime that causes chlorosis [12, 5, 11, 7, 10], especially when present in surface horizons (over 40 cm) [14].

Summary of water and nutrient requirements and sensitivity of the Common walnut for

<table>
<thead>
<tr>
<th>Water requirements</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity to temporary waterlogging</td>
<td>High</td>
</tr>
<tr>
<td>Nutrient requirements (Ca, Mg, K)</td>
<td>High</td>
</tr>
<tr>
<td>Nitrogen (and phosphorus) requirements</td>
<td>Moderate</td>
</tr>
<tr>
<td>Sensitivity to lime in fine soil</td>
<td>Low</td>
</tr>
</tbody>
</table>

Mineral nutrition of the Common walnut

Least demanding species
Minimum values for the growth of demanding species
Level of requirement of the species in question

DYNAMIC BEHAVIOUR AND CHARACTERISTICS

- Post-pioneer species [30].
- Adversely affected by herbaceous competition [26].
- Sensitive to Armillaria root rot (Armillaria mellea) and Phytophthora (Phytophthora cinnamomi) [7, 9]. In Spain, Zeuzera pyrina is a serious parasite, especially near fruit plantations [1].

Ecogram for the Common walnut

(according to Rameau and al., 1989, amended)

Main factors for the production of good quality timber

Limiting factors
- poor water supply, hydromorphy
- excessive competition for light
- early frosts, sharp temperature drops in winter, strong winds

Favourable factors
- deep, aerated, non-acidic soils, cool but not wet, sunny exposure, sufficient rainfall or abundant water reserves in the soil
Auteology of the
BLACK WALNUT

Juglans nigra L.

Fr. : Noyer noir
Sp. : Nogal negro Americano; Cat.: Noguer Negro
It. : Noce nero

This description is limited to features distinguishing the Black walnut from the Common walnut.

GEOGRAPHICAL DISTRIBUTION

- **Natural range**: Temperate eastern United States (from Atlantic coast to Nebraska, Kansas and Oklahoma in the west and from the Canadian border to Texas, Missouri, Alabama and Georgia to the south) [9]. This broad range explains why the species behaves variably, depending on the [7] origins of the plants.
- **Introduced in France in 1629** [30, 22].

![Distribution of Black walnut in North America](image)

Distribution of Black walnut in France

Distribution of Black walnut in France

CLIMATE AND TEMPERAMENT

**Bioclimatic conditions**
- Sensitive to late frost due to early budding (mid-April in the south-west, but variable according to the origin of the plants) [10, 9]; can be very sensitive to early frost [10].
- Root growth observed at ground temperature above 4 °C, with optimum root growth at 19 °C [23].
- Sensitive to gales during the growing period (gusts of wind, thunderstorms) causing breakage of branches or even trunks [7]. However, the stems grow vertically even in steady constant winds (mistral, etc.)

<table>
<thead>
<tr>
<th>Warmth Requirements</th>
<th>Sensitivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>cold</td>
<td>late frost</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

**Vegetation stages**
- Identical to Common walnut, except at < 800 m altitude.

**Temperament**
- Light: less demanding than the Common walnut, growing well, even thriving, in a forest environment [22] [7].
- Withstands competition better than the Common walnut [7, 10].
- Almost non-phototropic [77].
- Lateral shelter during the first years is beneficial [10].
Climatic limits
- **Resistant to cold** [9] down to -35 °C [26, 10].
- Rainfall: must be frequent and well-distributed (minimum 900 mm per year, [12]): **vulnerable to summer drought** (poor stomatal control and quick leaf fall) [10, 23], but withstands very hot weather if there are abundant water reserves.
- Atmospheric humidity favours the species.
- Requires a growing season of at least 140 days, ideally 170 days [6, 7].

SOILS

Water and drainage

**Water supply:**
- More demanding than the Common walnut.
- Growth is closely linked to the water supply (rain or ground water reserve) [15]. The species is severely affected by droughts [12].

**Waterlogging:**
- Withstands temporary waterlogging [12, 7, 29], but excessive water at the beginning of the growing period is detrimental [15].
- Avoid waterlogged soils to less than 60 cm in depth [10].

Drainage and excess water

<table>
<thead>
<tr>
<th>Natural drainage</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>h</th>
<th>i</th>
<th>e</th>
<th>f</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>excessive</td>
<td>good</td>
<td>moderate</td>
<td>imperfect</td>
<td>poor</td>
<td>very poor</td>
<td>partial</td>
<td>virtually non-existent</td>
<td>non-existent</td>
</tr>
<tr>
<td>b</td>
<td>redox horizon</td>
<td>absent or &gt; 90 cm</td>
<td>60-125 cm</td>
<td>40-80 cm</td>
<td>20-50 cm</td>
<td>0-30 cm</td>
<td>20-50 cm</td>
<td>0-30 cm</td>
<td>20-50 cm</td>
</tr>
<tr>
<td>c</td>
<td>with rust patches</td>
<td>no water table</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>&gt; 80 cm</td>
<td>40-80 cm</td>
</tr>
<tr>
<td>d</td>
<td>reductive waterlogged horizon</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

(from Species Ecology file, Ministry of the Walloon Region, 1991, amended [27])

Topographic situations:
- Alluvial plains (valleys of the Rhine and its tributaries, Saone and Yonne valleys, etc.) [7] and alluvial terraces; slopes, but avoid dry exposure (south, west) [6, 29].
- Grows well on the rich and cool areas of slopes and alluvial plains, especially in the Aquitaine basin on alluvial soils traditionally planted with poplar [19].

Favourable topographic situations for the Black walnut in terms of water supply

(Involved in the morpho-pedological compensations, to be modulated according to the other site characteristics)

Texture and materials
- the nature of the soil is the main factor limiting the **Black walnut tree**, which is more demanding than the Common walnut [8, 6, 29].
- Prefers **relatively balanced and well aerated soils** [30, 10, 29]; beware of excessively filtering soils, which are too dry on coarse sand or alluvium.
- Requires soils at least 1 m thick; if less, e.g. 60-80 cm, the ground must be very well aerated and constantly supplied with water (water table at a maximum depth of 1.50-2 m) [7, 29].
- **Avoid: compact clay soils and pseudo gleys** (with an impermeable layer), **poorly structured loams and stony soils** [7, 10, 29].

Textures favouring growth of the Black walnut

(Involved in the morpho-pedological compensations, to be modulated according to the climate and soil)

Autecology of Walnut species - p. 37
Nutrients
- Although not lime-intolerant, it does not grow well on limestone and is more tolerant of acidity, which corresponds to a range of pH from 5 to 7.5 [12, 7, 10, 25].
- Rather demanding in terms of nutrient minerals: gives the best results on rich sites [11, 19].
- Ideal: deep, well-drained loamy soils, rich in organic matter and minerals, such as alluvial soils (ash and elm stands) [29].

<table>
<thead>
<tr>
<th>Water requirements</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity to temporary waterlogging</td>
<td>Low</td>
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<td>Nutrient requirements (Ca, Mg, K)</td>
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<td>Moderate</td>
</tr>
<tr>
<td>Sensitivity to lime in fine soil</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

Summary of water and nutrient requirements and sensitivity of the Black walnut

DYNAMIC BEHAVIOUR AND CHARACTERISTICS
- Post-pioneer species [30].
- Not sensitive to Armillaria root rot (Armillaria mellea) [7].
- Grows better in forest conditions than the Common walnut, in mixed, high-density stands.

**MAIN FACTORS FOR THE PRODUCTION OF GOOD QUALITY TIMBER**

Limiting factors
- In particular, insufficient or irregular water supply on compact or excessively filtering soils
- Dry air, strong winds when in leaf and late frost. However, these risks can be mitigated by planting black walnut in protected locations or in a forest environment with appropriate tree care (form pruning)

Favourable factors
- Aerated and deep soils, cool but not wet, preferably rich but not acid, sunny exposure with sufficient rainfall or abundant water reserves in the soil
- High atmospheric humidity
The ecological requirements for this species are similar to those of the Common and Black walnut, with more or less marked characteristics of one or the other:
- Hybrid NG23 x RA is a little less sensitive to winter frost than the Common walnut and less sensitive to late frost than the Black walnut, due to later budding [12, 8, 5, 7].
- Hybrid MJ209 x RA appears more sensitive to cold (T. Avg. annual > 8 °C) than the hybrid NG23 x RA [3].
- This species appears less phototropic and less sensitive to shade than the Common walnut [5].
- Tolerates slightly acidic soils, up to pH 5 [3, 7, 10]; the hybrid MJ209 x RA is not sensitive to active lime and alkaline soils, but appears more sensitive to acid soils [3, 12, 10].
- Takes over most distinctly from its parents (the Common and Black walnut) on sites with a moderate water supply. Resistance to droughts and heatwaves appears to be intermediate between those of its parents.
- Optimum: well-structured and aerated clay-loam soils.
- Avoid heavy, waterlogged soils with an insufficient rate of saturation of exchangeable bases and pH values below 4 (oligotrophic soils) [3, 1].
- Very sensitive to herbaceous competition [3].

Comparison of requirements and site susceptibilities for walnut trees
(According to Becquey, 1997, amended [8])

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Common walnut</th>
<th>Black walnut</th>
<th>Hybrid walnut</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soil</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water requirements</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Susceptibility to temporary waterlogging</td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Nutrient requirements</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Susceptibility to active lime</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Climate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warmth requirement</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Rainfall requirement (during the season)</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Susceptibility to cold</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Susceptibility to late frost</td>
<td>Moderate</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>Susceptibility to early frost</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Susceptibility to wind</td>
<td>Moderate</td>
<td>High (summer, thunderstorms)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Susceptibility to drought</td>
<td>Low</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Light</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Susceptibility to competition for light</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Phototropic tendency</td>
<td>High</td>
<td>Low</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

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Authors: Marine Lestrade (CRPF-Midi-Pyrénées), Jacques Becquey (IDF), Jaime Coello (CTFC), Pierre Gonin (IDF), with the contribution of Eric Bruno (NFI) for the French distribution maps. Translators: Ilona Bossanyi-Johnson (ilona.bossanyi@wanadoo.fr), Mark Bossanyi (markbossanyi@gmail.com).

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