Comparative Study on Hydraulic Architecture Characteristic of *Pinus tabulaeformis* and *Platycladus orientalis* Seedlings

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**Abstract:** *Pinus tabulaeformis* and *Platycladus orientalis* are two different types of drought-tolerant tree species. In order to further understand the mechanisms of water transportation and drought tolerance, the present study, using the basic theory of hydraulic architecture, measured and analyzed the hydraulic architecture parameters of *P. tabulaeformis* and *P. orientalis* seedlings (4 years old) using improved flushing method with normal water supply. The results showed that both *P. tabulaeformis* and *P. orientalis* seedlings had constriction area. The stem diameter of seedlings in constriction area was higher than that in non-constriction area, while the hydraulic conductivity in constriction area was lower than that in non-constriction area. The existence of the constriction area is in favor of trunks and tops of trees for water capturing because the constriction area raises the resistance of water transportation of ramification, which is propitious to competition for survival of individual seedling. The hydraulic conductivities of *P. tabulaeformis* and *P. orientalis* seedlings increased with functional xylem diameter of stems, indicating that the water transportation capacity of thicker branches was higher than that of thinner ones. In the same size of functional xylem diameter, the hydraulic conductivity of *P. tabulaeformis* seedling was higher than that of *P. orientalis*, suggesting that the water transportation capacity of *P. tabulaeformis* seedling was higher than that of *P. orientalis*. The specific conductivities of *P. tabulaeformis* and *P. orientalis* seedlings increased logarithmically with functional xylem diameter of stems, indicating that porosity and water transportation efficiency of thicker branches were higher than that of thinner ones. The leaf specific conductivities of *P. tabulaeformis* and *P. orientalis* seedlings increased linearly with functional xylem diameter of stems. It is one of the important ecology strategies of drought tolerance for seedlings to survive in water stress, in which thinner, smaller and distal branches are harder to capture water than thicker ones, and they will be removed away from a “water-supply list” in order to guarantee the survival...
of the bigger apparatuses, such as trunks and thicker branches. The Huber value of *P. tabulaeformis* and *P. orientalis* seedlings increased linearly with functional xylem diameter, suggesting that the thicker the branches, the more the stem issues were involved in supplying water for distal leaf. In the same size of functional xylem diameter, the specific conductivity, leaf specific conductivity and Huber value of *P. tabulaeformis* were higher than those of *P. orientalis* seedlings. It suggested that *P. tabulaeformis* seedlings had higher efficiency of water transportation, lower water potential gradient and more stem issue involvement in supplying water for distal leaf than *P. orientalis* seedlings if water supply was enough and transpiration was the same.

**Key words:** *Pinus tabulaeformis; Platycladus orientalis; flushing method; hydraulic architecture*

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**1**

1.1

1.2

1.2.1

1.2.2

\[ A = 2L \left( 1 + \frac{\pi}{n} \right) \sqrt{nV/\pi L} \]

\[ y = 0.8694x - 0.9240 \quad (r = 0.9935, n = 116) \]

\[ y = 0.7923x - 0.0388 \quad (r = 0.9982, n = 108) \]
1. 2.3 Microsoft Excel

2

2.1

2.1.1

### Fig. 1
Effect of area stem segment of *Pinus tabulaeformis* seedlings located on hydraulic architecture
1. constriction area; 2. non-constriction area

### Fig. 2
Effect of area stem segment of *Platyedalus orientalis* seedlings located on hydraulic conductivity
1. constriction area; 2. non-constriction area

\[
y = 0.0327x^2 - 0.1541x + 0.2146 \quad (x \in [2, 18], r = 0.979, n = 82)
\]

\[
y = 0.0166x^2 - 0.0533x + 0.062 \quad (x \in [2, 20], r = 0.996, n = 85)
\]
图油松侧柏苗木功能木质部直径和导水率的关系

当油松和侧柏苗木导水率随功能木质部直径的变化可以分别用二项式和线性方程来模拟

其中

不难看出在功能木质部直径相同的情况下非限速区内油松的导水率同样高于侧柏

以功能木质部直径W毫米的茎段为例油松的导水率较侧柏高说明在非限速区内油松苗木功能木质部的导水能力也强于相同直径的侧柏苗木

在正常水分条件下油松和侧柏苗木非限速区内功能木质部直径和比导率之间呈对数相关

其中

根据实验和模拟的结果苗木功能木质部直径越大其导水效率越高在正常水分条件下油松苗木功能木质部直径LQ44茎段的比导率是LQ44侧柏苗木功能木质部直径LQ44茎段的比导率的倍这说明粗枝的孔隙度和水分运输效率远远高于细枝

一般来说相同直径油松苗木木质部的比导率高于侧柏苗木这种趋势随着茎段直径的增加而越发明显这说明油松苗木木质部的孔隙度和水分运输效率高于侧柏苗木

叶比导率是水力结构中表征茎段末端叶供水状况的重要指标当被茎段末断的叶干重或叶面积除时可得到即

如果已知道茎段上叶平均蒸腾流密度在忽略叶水势变化时由于水容量造成的含水量变化的情况下越高说明茎段末端单位叶面积的供水情况越好需要由茎给其末端叶供水所需的压力梯度越小
图 4 《生态学报》第 18 卷第 6 期

图 5 《生态学报》第 18 卷第 6 期

4.1 功能木质部直径和叶比导率的关系

功能木质部直径和叶比导率的关系

油松和侧柏苗木功能木质部直径和比导率的关系

实验和模拟的结果表明，随着功能木质部直径的增加，油松和侧柏苗木的叶比导率增大。例如，油松苗木功能木质部直径的叶比导率是直径叶比导率的 1.2 倍。侧柏苗木功能木质部直径的叶比导率是直径叶比导率的 1.1 倍。这意味着在平均蒸腾流密度相同的情况下，侧柏茎段水分运输所需克服的阻力是径段的 1.2 倍。这说明功能木质部直径越粗的枝条，其为单位末端叶供给水分所投入的茎干组织越多。但就相同功能木质部直径的茎段而言，油松苗木的叶比导率高于侧柏苗木。以功能木质部直径的茎段为例，油松苗木的叶比导率是侧柏苗木的 1.2 倍。说明在平均蒸腾流密度相同的情况下，相同直径的油松苗木较侧柏苗木更易获得水分。

胡伯尔值的变化

胡伯尔值反映的是供给单位茎末端叶面积或叶干重水分的边材横截面积。如环孔材或有时是茎横截面积。胡伯尔值越大，说明维持单位叶面积水分供给的茎干组织越多。从图 4 可以看出，用线性方程可以较好的模拟油松和侧柏苗木非限速区内功能木质部直径和胡伯尔值之间的相关关系。其中，为胡伯尔值；为功能木质部直径；为相关系数；为样本数。实验和模拟的结果表明，随着功能木质部直径的增加，油松和侧柏苗木的胡伯尔值呈线性增加。比如，油松苗木功能木质部直径的茎段，其胡伯尔值是直径茎段胡伯尔值的 1.2 倍。侧柏苗木功能木质部直径的茎段，其胡伯尔值是直径茎段胡伯尔值的 1.1 倍。说明功能木质部直径越粗的枝条，其为单位末端叶供给水分所投入的茎干组织越多。但就相同功能木质部直径的茎段而言，油松苗木的胡伯尔值高于侧柏苗木。以功能木质部直径的茎段为例，油松苗木的胡伯尔值是侧柏苗木的 1.2 倍。说明油松苗木为单位末端叶供给水分所投入的茎干组织较侧柏苗木多。
图2

图2 油松侧柏苗木功能木质部直径和胡伯尔值的关系

结论

油松和侧柏苗木都存在水分运输的限速区。尽管其功能木质部直径高于对应非限速区，但其导水率却低于对应非限速区。限速区的存在增大了分枝水分运输的阻力，使苗木的水分分配更有利于主干和顶梢等分枝较少的部位，有利于苗木个体的生存竞争。无论在限速区还是在非限速区，油松和侧柏的导水率都随功能木质部直径的增加而增大。但在功能木质部直径相同的情况下，油松苗木的导水率高于侧柏，说明油松苗木功能木质部的导水能力高。在非限速区可以用二项式来模拟导水率和茎段直径的相关关系，在限速区则可用线性方程模拟二者之间的相关关系。油松和侧柏的胡伯尔值都随功能木质部直径的增加而呈对数增长，说明粗枝的孔隙度和水分运输效率远远高于细枝。同时油松的胡伯尔值高于侧柏，说明在功能木质部直径相同的情况下，油松苗木木质部的孔隙度和水分运输效率较侧柏苗木高。在非限速区可以用二项式来模拟导水率和茎段直径的相关关系，在限速区则可用线性方程模拟二者之间的相关关系。油松和侧柏的比导率都随功能木质部直径的增加而呈线性增长。这说明较粗的枝条较多次分枝的末端细小枝条更易获得水分。在油松和侧柏中，水分运输的主要阻力集中于那些细小的末端分枝。这样，苗木在水分胁迫的情况下将首先牺牲那些光合积累较小的枝条，而尽可能保证主干和力枝等光合积累较大器官的供水和存活，这是油松侧柏苗木抵御干旱胁迫的重要生态策略之一。但油松的叶比导率高于侧柏，说明在平均蒸腾流密度相同的情况下，相同直径的油松苗木较侧柏苗木更易获得水分。油松和侧柏的胡伯尔值都随功能木质部直径的增加而呈线性增长，说明功能木质部直径越粗的枝条，其为单位末端叶供给水分所投入的茎干组织越多。同时油松的胡伯尔值高于侧柏，说明油松苗木为单位末端叶供给水分所投入的茎干组织较侧柏苗木多。

参考文献