

# 刺梨实生苗对硝态氮、铵态氮的吸收与利用差异分析

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**摘要:**【目的】研究刺梨(*Rosa roxburghii* Tratt.)对 $\text{NO}_3^-$ 、 $\text{NH}_4^+$ 的吸收动力学特性及其利用差异,探究不同供氮浓度和不同温度条件下刺梨对 $\text{NO}_3^-$ 和 $\text{NH}_4^+$ 的吸收特性,为刺梨氮肥施用提供科学依据。【方法】以‘贵农5号’刺梨品种实生苗为材料,采用耗竭法和砂培试验的方法,测定了供给不同形态及配比的氮素后刺梨实生苗对 $\text{NO}_3^-$ 和 $\text{NH}_4^+$ 的吸收动力学参数及氮素的吸收量与利用效率,研究不同供氮浓度及温度变化和不同硝铵比氮素条件下刺梨实生苗对 $\text{NO}_3^-$ 和 $\text{NH}_4^+$ 的吸收与利用效率的差异。【结果】刺梨根系对硝态氮、铵态氮及总氮的吸收规律均符合Michaelis-Menten酶动力学方程。在不同浓度的 $\text{NO}_3^-$ 、 $\text{NH}_4^+$ 条件下,刺梨根系对 $\text{NO}_3^-$ 的最大吸收速率、亲和力及在根系中的流速始终高于 $\text{NH}_4^+$ 。在硝态氮与铵态氮不同配比的供氮条件下,根系对 $\text{NO}_3^-$ 、 $\text{NH}_4^+$ 的最大吸收速率和 $\text{NO}_3^-$ 、 $\text{NH}_4^+$ 在根系中的流速都随着硝、铵比例的增加而增大,硝铵比为3:1的供氮条件下,刺梨根系对总氮的吸收速率和总氮在根中的流速最大,最有利于刺梨对氮素的吸收,刺梨实生苗的生物量、总氮的吸收量和氮的利用效率最大。介质的温度过低或过高都会降低刺梨根系对 $\text{NO}_3^-$ 和 $\text{NH}_4^+$ 的吸收,显著降低 $\text{NO}_3^-$ 、 $\text{NH}_4^+$ 的最大吸收速率和 $\text{NO}_3^-$ 、 $\text{NH}_4^+$ 在根系中的流速;无论温度如何变化,刺梨根系对 $\text{NO}_3^-$ 的最大吸收速率和 $\text{NO}_3^-$ 在根系中的流速始终比 $\text{NH}_4^+$ 高。在20~25℃有利于刺梨对 $\text{NO}_3^-$ 和 $\text{NH}_4^+$ 的吸收。【结论】刺梨具有偏好吸收硝态氮的特性,在单纯供给硝态氮或混合供给硝铵态氮硝铵比1:1及以上的条件下,刺梨实生苗根系对 $\text{NO}_3^-$ 的最大吸收速率、亲和力和 $\text{NO}_3^-$ 在根系中的流速始终比 $\text{NH}_4^+$ 高,刺梨偏好硝态氮的特性不会因介质中 $\text{NO}_3^-$ 和 $\text{NH}_4^+$ 的浓度及温度的变化而改变。介质温度20~25℃有利于刺梨对氮的吸收,供给硝铵比3:1的氮肥最有利于刺梨实生苗的生长,生物量、氮素吸收量最大,氮素利用效率最高。

**关键词:** 刺梨;硝态氮;铵态氮;吸收动力学;氮利用效率

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## Differences in absorption and utilization of nitrate nitrogen and ammonium nitrogen in the seedling of *Rosa roxburghii*

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**Abstract:** 【Objective】*Rosa roxburghii* Tratt. is one of the most important fruit trees in southwestern China. The content of vitamin C in 100 g of *R. roxburghii* can be higher than 2 000 mg, which attracts the attention of fruit industry and academia. The production of *R. roxburghii* in the southwest region of China is expanding. So far, the absorption and utilization characteristics of different forms of nitrogen in the crop have not been well defined, and therefore there is a lack of information about nitrogen nutrition management for the crop. In this study, we investigated the absorption kinetics, the uptake efficiency and nitrogen utilization efficiency of  $\text{NO}_3^-$  and  $\text{NH}_4^+$ . The differences in the uptake and utilization efficiency of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  were studied under different nitrogen concentrations and temperatures, and the effects of supply of different proportions of nitrate and ammonium nitrogen were studied. The purpose of this study was to provide the theoretical guidance for the selection of nitrogen fertilizer in the cultivation of *R. roxburghii*. 【Methods】In this study, the seedlings of *R. roxburghii* Tratt. ‘Guinong 5’ were used as the material. The

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Hoagland and Arnon nutrient solution formula and sand culture were used in the nitrogen treatments. Five nitrogen treatments were set with different ratios of  $\text{NO}_3^-$  to  $\text{NH}_4^+$ , i.e. 1:0, 1:3, 1:1, 3:1 and 0:1, and seedlings biomass, nitrogen absorption and utilization efficiency were investigated after 60 d of the treatments. Depletion method were adopted to measure the affinity, the maximum absorption rate ( $I_{\max}$ ) and the flow velocity ( $\alpha$ ) of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  in root under different concentrations and proportions of  $\text{NO}_3^-$  and  $\text{NH}_4^+$ . This study also analyzed the effects of different temperatures on absorption kinetics of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  ions after supplied with  $\text{NO}_3^-$  or  $\text{NH}_4^+$  at the concentration of  $2.0 \text{ mmol} \cdot \text{L}^{-1}$ . [Results] The absorption pattern of nitrate nitrogen, ammonium nitrogen and total nitrogen followed the Michaelis-Menten kinetics equation. The preference of nitrate nitrogen absorption did not change due to the changes in  $\text{NO}_3^-$  and  $\text{NH}_4^+$  ions or temperature in the medium. The results provided important scientific basis for selection of nitrogen fertilizer. When  $\text{NO}_3^-$ -N or  $\text{NH}_4^+$ -N was supplied alone, the maximum absorption rate, affinity and flow velocity of  $\text{NO}_3^-$  were higher than those of  $\text{NH}_4^+$ , and this characteristic was irrespective with the changes in the concentrations of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  ions. The  $I_{\max}$  and  $\alpha$  values of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  were significantly decreased by extreme temperatures in the medium, but the values of  $I_{\max}$  and  $\alpha$  of  $\text{NO}_3^-$  were always higher than those of  $\text{NH}_4^+$ .  $30 \text{ }^\circ\text{C}$  resulted in the lowest maximum root absorption, affinity and flow rate of  $\text{NH}_4^+$ , and  $5 \text{ }^\circ\text{C}$  had the lowest flow rate of  $\text{NO}_3^-$ . The maximum root absorption rate of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  was maximum at  $25 \text{ }^\circ\text{C}$  and  $20 \text{ }^\circ\text{C}$ , respectively; the affinity of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  reached the maximum value at  $25 \text{ }^\circ\text{C}$  and  $15 \text{ }^\circ\text{C}$ , respectively; and the flow rates of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  in roots was highest at  $25 \text{ }^\circ\text{C}$  and  $15 \text{ }^\circ\text{C}$ , respectively. The  $I_{\max}$  values and  $\alpha$  values of  $\text{NO}_3^-$  and  $\text{NH}_4^+$  increased with the increase in the ratio of nitrate nitrogen to ammonium nitrogen. When the ratio was 3:1, the total nitrogen content of the roots was the highest, suggesting this ratio was favorable for nitrogen absorption. In the sand culture experiment, the nitrogen use efficiency as well as the biomass and N uptake were all highest in the treatment with 3:1 ratio of nitrate nitrogen to ammonium nitrogen. [Conclusion] *R. roxburghii* has nitrate preference, and the maximum root absorption, the affinity and the flow rate of  $\text{NO}_3^-$  are always larger than those of the  $\text{NH}_4^+$ . Changes in nitrogen concentration and temperature do not affect the priority in absorption of  $\text{NO}_3^-$ . The maximum absorption of nitrogen occurs under the temperature of  $20\text{--}25 \text{ }^\circ\text{C}$ . The biomass, N uptake, and thus the nitrogen use efficiency can be further improved with the ratio of  $\text{NO}_3^-$ -N:  $\text{NH}_4^+$ -N of 3:1.

**Key words:** *Rosa roxburghii*; Nitrate; Ammonium; Absorption kinetics; Nitrogen use efficiency

刺梨 (*Rosa roxburghii* Tratt.) 是我国的特色果树, 因其果实中维生素 C 质量分数极高 ( $20\ 540\text{--}27\ 280 \text{ mg} \cdot \text{kg}^{-1}$ , 以鲜质量计) 而备受关注<sup>[1]</sup>。近年来我国西南地区刺梨种植面积日益扩大, 在生产中有关刺梨氮素营养管理尚无深入的研究。笔者过去的研究发现, 在混合供应硝态氮和铵态氮的条件下, 增大硝态氮的比例能够促进刺梨的生长<sup>[2]</sup>, 但这一结果是否与刺梨对硝、铵离子吸收的差异性有关尚未确定。植物根系对离子的最大吸收速率、与离子的亲和力及离子在根中流速这 3 个离子吸收动力学参数, 是反映植物对离子吸收能力的重要指标, 其中离子最大吸收速率 ( $I_{\max}$ ) 与离子的载体数量及转运效

率有关,  $I_{\max}$  越大, 反映植物吸收某种离子的内在潜力越大。根系与离子的亲和力常用表观米氏常数 ( $K_m$ ) 表示, 它反映离子载体活性中心与离子亲和力的大小,  $K_m$  越小, 亲和力越强<sup>[3-4]</sup>。通常用  $I_{\max}$  和  $K_m$  的比值 ( $\alpha$ ) 表示离子流入根系的速率,  $\alpha$  值越大, 离子流入根系的速度越快。前人的研究证实了甜橙 (*Citrus sinensis*)<sup>[5]</sup>、枇杷 (*Eriobotrya japonica*)<sup>[6]</sup>、香蕉 (*Musa nana*)<sup>[7]</sup>、小麦 (*Triticum aestivum*)<sup>[8]</sup>、菠菜 (*Spinacia oleracea*)<sup>[9]</sup>、蓝莓 (*Vaccinium corymbosum*)<sup>[10]</sup>、落叶松 (*Larix gmelini*)<sup>[11]</sup>、花旗松 (*Pseudotsuga menziesii*)<sup>[12]</sup> 和红松 (*Pinus koraiensis*)<sup>[13]</sup> 等植物选择吸收硝、铵离子的差异性与离子吸收动力学参数密切相关, 并将供