水氮耦合对轮伐末期毛白杨纸浆材生长及土壤水养特征的影响

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摘要：【目的】水肥耦合被普遍认为是提高林地生产力最有效的措施之一，但目前国内研究多为短期水氮效应研究，缺乏轮伐期末对毛白杨纸浆材水氮耦合的探讨，本文旨在明确轮伐期末毛白杨最佳灌溉施肥策略。【方法】本文以栽植于鲁西北平原的三倍体毛白杨为研究对象，采取大田滴灌水氮耦合试验，研究灌溉施肥后的第四个生长季内（4 月~10 月）各水氮处理的叶面积指数（LAI）、土壤体积含水率（SVWC）的时空动态变化和生长季末林木生长和林地土壤养分规律，从而确定轮伐末期最佳的施肥策略。【结果】（1）毛白杨纸浆材轮伐末期林分充分郁闭，对水、养资源的竞争转变为对空间和光资源的竞争，从而导致不同水氮条件下林木生长、林地蓄积（V）和林地生产力（AFP）无显著差异；（2）水氮耦合不能改变叶面积指数（LAI）在生长季内的变化趋势，在整个生长季 LAI 呈递减趋势，但因风灾（6 月 1 日发生）呈双峰状，5 月 30 日和 7 月 15 日前后达到峰值；（3）灌溉量、土壤深度和月份是影响土壤体积含水率的主要因子；春季（5 月）灌溉处理能够增加 0~200 cm 土壤深度的 SVWC，其中充分灌溉水平（W20）主要增加根区土壤表层水分，控制（W33）及亏却灌溉(W45)主要增加 100~150 cm 深度水分；夏季（7 月），灌溉能够增加 0~200 cm 深度 SVWC，充分灌溉（W20）对土壤水分的补充优于 W33 和 W45 水平。秋季停止灌溉后（10 月），W20 和 W33 水平的深层土壤含水率较高，深层土壤水分得到补充，而秋季的表层土壤相比春、夏季变得更为干燥；（4）各处理毛白杨林分中土壤养分主要积累在的浅土层（0~40 cm 土层），浅土层土壤有机质和全氮含量对水氮耦合的响应弱于有效磷，其中灌溉对有效磷的积累作用大于施肥；（5）5 年生毛白杨林木胸径（DBH）和树高（H）与林地蓄积量（V）成极其显著正相关，林木树高和叶面积指数呈显著负相关土壤速效磷含量与林木胸径之间具有显著的正相关关系，施氮可通过促进土壤磷含量的积累从而促进林木生长。【结论】连续四年水氮耦合对五年生毛白杨纸浆材生长无明显促进作用，且对土壤养分改善效果有限，建议应在相近立地条件下，短轮伐期毛白杨纸浆材培育末期停止施肥，保持充分灌溉（灌溉阈值为-20 kPa），从而实现地力可持续。

关键词：水肥耦合；毛白杨；林木生长；土壤水养特征

Effect of water and nitrogen coupling on the growth and soil hydrotropic characteristics of *populus tomentosa* pulpwood at the end of rotation

Abstract:【Objective】Water-fertilizer coupling is widely considered as one of the most effective measures to improve the productivity of forest land, but at present, most of the domestic researches are short-term water and nitrogen effect researches, and there is a lack of exploration of water and nitrogen coupling of *populus tomentosa*

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pulpwood at the end of the rotation period, and this paper aims at clarifying the optimal irrigation and fertilization strategy of *populus tomentosa* at the end of the rotation period.【Method】In this paper, we take the triploid *populus tomentosa* planted in the Northwest Shandong Plain as the research object, and adopt the drip irrigation water-nitrogen coupling test to study the spatial and temporal dynamics of leaf area index (LAI), soil volumetric water content (SVWC) of each water-nitrogen treatment in the fourth growing season (April~October) after irrigation and fertilization, as well as the growth of the trees at the end of the growing season and the nutrient pattern of the forest land, so as to determine the best fertilization strategy at the end of the rotational logging period.【Result】(1) At the end of the rotation of *Populus tomentosa* pulpwood, the stand was fully closed, and the competition for water and nutrient resources was changed to competition for space and light resources, which resulted in no significant differences in stand growth, stand volume (V), and stand productivity (AFP) under different water and nitrogen conditions. (2) Water-nitrogen coupling could not change the trend of leaf area index (LAI) within the growing season, which showed a decreasing trend throughout the growing season, but was bimodal due to wind damage (which occurred on June 1), peaking around May 30 and July 15. (3) Irrigation, soil depth and month were the main factors affecting soil volumetric water content; in spring (May), irrigation treatments were able to increase SVWC from 0 to 200 cm soil depth, with the full irrigation level (W20) mainly increasing soil surface water in the root zone, and control (W33) and deficit irrigation (W45) mainly increasing water from 100 to 150 cm depth. In summer (July), the irrigation was able to increase SVWC from 0 to 200 cm depth, and full irrigation (W20) supplemented soil moisture better than W33 and W45 levels. After irrigation was stopped in the fall (October), deeper soil water content was higher and deep soil moisture was replenished at the W20 and W33 levels, whereas top soil became drier in the fall compared to spring and summer.(4) Soil nutrients were mainly accumulated in the shallow soil layer (0~40 cm soil layer) of the *Populus tomentosa* stands in each treatment, and the response of soil organic matter and total nitrogen content in the shallow soil layer to water-nitrogen coupling was weaker than that of effective phosphorus, in which the accumulation of effective phosphorus by irrigation was greater than that by fertilization. (5) Diameter at breast height (DBH) and tree height (H) of 5-year-old *Populus tomentosa* forests were significantly positively correlated with forest volume (V), and tree height and leaf area index were significantly negatively correlated. Soil quick-acting phosphorus (AP) content had a significant positive correlation with DBH, and nitrogen application could promote forest growth by facilitating the accumulation of soil phosphorus. Nitrogen application can promote the growth of forest trees by promoting the accumulation of soil phosphorus content.【Conclusion】Four consecutive years of water-nitrogen coupling did not significantly promote the growth of five-year old *Populus tomentosa* pulpwood and had limited effect on soil nutrient improvement, so it is recommended that fertilizer application should be stopped at the end of the cultivation period of *Populus tomentosa* pulpwood in the short-rotation logging period under similar standing conditions and adequate irrigation should be maintained (irrigation threshold of -20 kPa), so as to realize the sustainability of land strength.

Key words: coupling effects of water and fertilizer; *Populus tomentosa*; forest tree growth; soil hydroponic characteristics