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Long-term impact of prescribed burning on water use efficiency, biological nitrogen fixation, and tree growth of understory acacia species in a suburban forest ecosystem of subtropical Australia

Sabah Taresh[1,2] · Shahla Hosseini Bai[1] · Kadum Mohammed Abdullah[1,3] · Jacinta Zalucki[1] · Ashrafun Nessa[1] · Negar Omidvar[1] · Dianjie Wang[1] · Juan Zhan[1] · Fang Wang[1] · Jiaping Yang[1] · Edith Kichamu-Wachira[1] · Zhihong Xu[1]

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Abstract

Purpose Prescribed burning is a useful tool in a suburban forest of subtropical Australia for bushfire risk management. Toohey Forest has been managed by controlled burns and was used in this study. This study examined the long-term impacts of prescribed burning on biological nitrogen fixation (BNF) of understory acacia species estimated by ^{15}N natural abundance method, water use efficiency (WUE) as reflected in foliar carbon isotope composition ($\delta^{13}C$), and plant growth 6–14 years after prescribed burning in a suburban Toohey forest ecosystem of subtropical Australia.

Materials and methods Four sites (S1, S2, S3, and S4) were established in Toohey Forest, Queensland, Australia. Foliar samples were collected from two understory species of acacia (*A. leiocalyx* and *A. disparimma*) and reference plants (*E. psammitica*) at each study site for three seasons (growing seasons of Spring October 2018 and Autumn May 2019, and non-growing season of Winter August 2019).

Results and discussion Foliar total nitrogen (N) concentrations of *A. leiocalyx* were higher at sites of S1, S3, and S4 than those of *A. disparimma* after 6–14 years of prescribed burning. Both species still depended upon BNF for their N supply, with a higher dependence maybe in winter than in summer at S3. The highest BNF rates for *A. leiocalyx* at all sites were also found in the winter of August 2019, while the lowest BNF rates were detected during the autumn of May 2019. The BNF was estimated as 56.5% for *A. leiocalyx* and 52.8% for *A. disparimma* at S1, with the corresponding values of 74.6% at S2, 63.4% at S3, and 85.0% at S4, respectively. This study demonstrates that *A. disparimma* for S1, S2, S3, and S4 had relative higher WUE than *A. leiocalyx* in the winter of August 2019 after 6–14 years of prescribed burning. There was a significant higher plant growth rate (tree height) of *A. leiocalyx* at sites of S1, S2, and S4, compared with that of *A. disparimma*.

Conclusions Both young acacia plants were more active in BNF than older plants, with the BNF peaked between 6 and 8 years after prescribed burning. Conversely, BNF was lower after 9–14 years of prescribed burning. There were significant and positive relationship between foliar $\delta^{13}C$ and $\delta^{15}N$, highlighting the role of BNF in improving plant WUE and subsequently tree growth in the suburban native forest.

Keywords Biological nitrogen fixation · Understorey *Acacia* spp. · Water use efficiency · Plant growth

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✉ Sabah Taresh
sabah.taresh@griffithuni.edu.au

✉ Zhihong Xu
zhihong.xu@griffith.edu.au

[1] Centre for Planetary Health and Food Security, School of Environment and Science, Griffith University, Nathan, QLD 4111, Australia

[2] Date Palm Research Centre, University of Basrah, Basrah, Iraq

[3] Plant Protection Department, College of Agriculture, University of Kerbala, Kerbala, Iraq