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Masting changes canopy structure, light interception, and photosynthesis in *Fagus crenata*

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Highlights: Masting-dependent changes in canopy structure, light interception, and photosynthesis in natural *Fagus crenata* forests were examined with field-research and light transfer model. Masting significantly decreased canopy leaf area, especially in the upper layer, but increased whole canopy photosynthesis because of increased light interception in the lower layer. These masting-dependent changes are important for precise carbon budget estimation in forest ecosystems.

Keywords: Masting, canopy, structure, light interception, photosynthesis, Fagus crenata Blume

Synchronous intermittent production of large seed crops in perennial plant populations is called masting. Several studies have shown that masting reduces shoot length and leaf area, most likely because of the high resource demands of fruit production. Although structural changes in shoots can affect canopy light interception and photosynthesis, no studies have been carried out to quantify such impacts. Because fruit production in *Fagus* trees relies on current photoassimilation rather than internal storage of carbohydrates (Hoch 2005, Hoch et al. 2013), precise prediction of canopy structure, light interception, and photosynthesis in mast years is essential for understanding eco-physiological mechanisms of masting. Consequently, the primary objective of this study was to examine the impact of masting on canopy structure and photosynthesis in *F. crenata* forests.

The study was conducted in natural *F. crenata* forests on Naeba Mountain in Japan (36°51'N, 138°40'E). A total of 40 branches, 40–60 cm long, were collected from sunlit portions of the canopy during summer (July–August) in mast (2009, 2011) and non-mast (2010, 2012) years. Fruit mass, current-year shoot length, leaf number, total leaf area, and light interception efficiency (silhouette to projected area ratio, SPAR) was measured for each branch. Three-dimensional (3D) distribution of branch leaf area was measured in non-mast years (2008, 2010) using the vertical point quadrat method (Iio et al. 2011), and that in mast-years was estimated from spatial distribution of branch fruit mass measured for heavy mast trees in 2009 and from the dependence of branch leaf area on the fruit mass. Light response curves of leaf and fruit gas exchange rates were also measured at sunlit portions of canopy across growing season (May to October) in mast and non-mast years (leaves only). Canopy photosynthesis under heavy mast and non-mast conditions was calculated for 11 mature trees using the light response curves, 3D distribution of leaf area and SPAR, and a light transfer model based on a Monte-Carlo ray tracing approach (Iio et al. 2011).

Although various branch structural parameters were measured, significant impact of masting was found only for leaf area; leaf area decreased with increasing fruit mass. As a consequence, total leaf area of heavy mast canopy was 15% lower than that of non-mast canopy. Canopy photosynthesis in summer, however, was 11% higher under heavy mast conditions than under non-mast conditions. Fruit photosynthetic rate was always lower than the respration rate, and there were no clear differences in leaf photosynthetic capacity between mast and non-mast years. The increase in canopy photosynthesis is thus because the reduction in leaf area occurred primarily in the upper layer, the site of heaviest fruit production, with the resulting increased light interception in the lower layer exceeding the reduction in photosynthesis in the upper layer. My study showed that canopy photosynthesis in *F. crenata* increases in mast year due to release from significant leaf self-shading within the canopy.

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