学 位 論 文 内 容 の 要 旨

博士（環境科学）　　　　　　　　　　氏　名 Sunmonu Azizat Idowu

学 位 論 文 題 名

Carbon allocation strategies for reproduction and growth in spring ephemeral plants
（春植物における繁殖と成長への炭素分配戦略）

Spring ephemerals constitute part of the herb layer in the temperate deciduous forests and are characterized by a relatively short growth period from snowmelt to canopy closure. These plants are faced with declining photosynthetic carbon gain because light availability consistently decreases from spring to summer due to leaf emergence of canopy trees. Previous studies have shown that spring ephemerals commonly have high reproductive output even under decreasing light intensity and short growth period, but the strategy and mechanisms responsible for active reproductive output have been studied only for restricted species. In addition, the effect of decreasing light intensity and changing environmental conditions on both vegetative and reproductive functions is poorly understood. The purpose of this study is to clarify the mechanisms of reproductive compensation and carbon allocation strategy under fluctuating light and temperature environments using a model plant, *Gagea lutea* (Liliaceae).

In Chapter 1, the mechanism to mitigate the cost of reproduction was clarified by monitoring leaf and bract growth and carbon fixation, bulb growth, and seed production. Leaf growth, foliar and non-foliar (bract) photosynthetic activities, and total assimilation were compared among reproductive-intact, floral-bud removal, and vegetative plants. Translocation of current photosynthetic products to individual organs was quantified by a $^{13}CO_2$-trace experiment. Bulb growth was compared between hand-pollination and floral-bud removal treatments, and seed set was compared between intact, leaf-clipping and bract-clipping treatments. Fruit-forming plants retained leaves longer than vegetative and floral-bud removal plants, but the assimilative contribution of extended leaf longevity was negligible. Carbon supply by bract photosynthesis was large enough for fruit development. Leaf photosynthetic products were largely transported to bulbs. The leaf-clipping had no effect on seed production, while the bract-clipping significantly reduced the seed production. Therefore, current photosynthesis of leafy bracts was a major carbon source for fruit development. This self-compensative mechanism of reproductive structure enables the continuous reproductive activity in this species.

In Chapter 2, the effects of shading by early canopy closure on reproductive output and vegetative growth were clarified. With a bract removal treatment (source reduction) and a floral-bud removal treatment (sink reduction) under canopy and open conditions, the effects of sink-source balance on seed production and bulb growth were investigated. Leaf carbon fixations did not differ between the forest and open sites and among treatments. Bract carbon fixations were also similar between sites but tended to decrease when floral buds were removed. Seed production was higher under open condition and decreased by the bract-removal treatment under both light conditions. Although bulb growth was independent of light conditions and the bract removal treatment, it was increased greatly by the bud removal treatment. Therefore, leaves and bracts acted as specialized source organs for vegetative and reproductive functions, respectively, but photosynthetic products by bracts were flexibly used for bulb growth when plants failed to set fruits. Extension of bright period was advantageous for seed production (i.e., source limited) but not for vegetative growth (i.e., sink limited) in this species.

In Chapter 3, the effects of temperature on reproduction and vegetative growth were tested to predict the fate of spring ephemerals under warm spring. By monitoring both reproducing and non-reproducing individuals, leaf physiological activities, bulb growth and seed set success were compared among plants grown in forest, open, and greenhouse conditions. Environmental variables of each site were also recorded. Photosynthetic active radiation, soil temperature and air temperature all have higher value in the greenhouse leading to earlier snowmelt and earlier growth initiation. Leaf photosynthetic activity (P_{max}) was inhibited at high temperature, and dark respiration (R_d) increased as the season progresses, while trend in stomatal conductance was not clear. Interestingly, final bulb size was larger under warm conditions in reproductive plants but decreased in the non-reproductive plants. Reduced seed set was recorded under warm conditions in the greenhouse. It is suggested that bulb development under warming might be status dependent especially for species with separate and flexible carbon source for seed production; bulb growth in non-reproductive plants may be decreased but the level of reproduction may determine the extent in the reproductive plants.

This study provides a new explanation for the mechanisms responsible for high reproductive output in spring ephemerals. Total carbon fixation by each of bract and leaf is directed towards current reproduction (seed production) and storage for future growth and reproduction (bulb growth), respectively. This carbon allocation results in the negligible cost of reproduction in this species. The possibility of increased carbon assimilation under bright and cool conditions is beneficial for reproduction, but warmer temperature and subsequent earlier canopy closure may inhibit the seed production. These responses predict that spring ephemerals may be the most sensitive species to global warming in the northern forest ecosystem.