LONG-DAY AND SHORT-DAY TREE SPECIES AMONGST *CONIFERAE*

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松柏類における長日及び短日樹種

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There exist growth and differentiation of plant organ and tissue response to day-length. This physiological phenomenon is called "photoperiodism". Since the studies of Garner and Allard (1920), this disposition of plant has become a very interesting research problem. Though day-length has much to do with growth, dormancy and the other properties of plants, the relation to flowering is most remarkable.

It has long been known that the flowering of a plant is under the control of day-length. Exposure to day-light during a normal period leads a plant to flower. According to the mode of response to day-length, plants have been classified as follows:

Long-day plant: when day-length is longer than 12 hours, flowering proceeds normally, and when shorter than 12 hours, flowering delays or ceases.

Short-day plant: when day-length is shorter than 12 hours, flowering proceeds normally, and when longer than 12 hours, flowering delays or ceases.

Intermediate plant: response to day-length is intermediate between above two.

Photoperiodism has been subjected to experiment and discussed mainly on annual and perennial herbaceous plants, and there have been few researches on forest tree species. It is natural that there are distinguishable differences in the mode of response to light between forest trees and herbaceous plants. In the case of forest trees, the winter falls in the period from the differentiation of flower bud to their flowering season. Therefore, the classification into either short-day or long-day tree species cannot be based only on the flowering season of the species. For examples:

Pinus densiflora (in Tottori district): differentiation of flower bud—July, meiosis of pollen mother cell—last part of April in the following year, flowering season—beginning of May, meiosis of embryo-sac mother cell—beginning of July, germination of pollen grains—end of June of the second year following.

Cryptomeria japonica: differentiation of male flower—beginning of July, that of female flower—beginning of August, meiosis of pollen mother cell—middle part of September, flowering season—middle part of March of the succeeding year, germination of pollen grains—May.

Thujopsis dorabrata: meiosis of pollen mother cell—January.

Chamaecyparis obtusa: meiosis of pollen mother cell—February. It may be observed that the season of meiosis of above-mentioned tree species is scattered through a year, though the season of differentiation of their flower bud usually falls in July and August. The morphological differentiation of male flower and female flower comes after meiosis in *Pinus densiflora*, but it comes before meiosis in *Cryptomeria*.

The exact determination of the transition from vegetative growth to reproductive growth should depend on the development of reproductive cells as a result of meiosis. The growth of the flower bud, external-morphologically differentiated without developing reproductive cell, cannot be regarded as reproductive growth in a strict sense. In *Cryptomeria*, formation of flower buds occurs prior to meiosis. Male or female flowers, once differentiated, sometimes return to the stage of vegetative growth in nature, and it is possible to cause new shoots to grow on the top of stobiles by pinching the upper shoots. Occurrence of physiological condition in a cell from which meiosis is derived, is due to the physiological qualities of tree species and environment factors. Plant response to short day treatment or long day treatment is based on some changes in physiological equilibrium in the constituents of nutrition in the cell, caused by the effect of light. Examples are: increase of carbohydrate in the cell by long-day treatment varies the ratio of carbohydrate—nitrogen (C/N) and then the transition from vegetative growth to reproductive growth follows visible as the differentiation of the sexual organs. Meiosis in *Pinus densiflora* and *Pinus Thunbergii* occurs in the long-day season towards the summer solstice (about one month after spring equinox) whilst, on the contrary, in *Cryptomeria* it occurs in the season towards the winter solstice (about autumnal equinox). Occurrence of meiosis in the opposite two seasons of a year on above two tree species indicates the existence of great differences in their physiological qualities. Meiosis in some other tree species such as *Chamaecyparis obtusa* and *Thujopsis dolabrata*, takes place in the intermediate season between the above two (in the winter).

There are two growing seasons of trees in a year, spring and autumn, and the season of transition from vegetative growth to reproductive growth agrees with the beginning or the end of each growing season. In midsummer, vegetative growth loses its vigor and in midwinter, even in a warm region, it becomes feeble too. In cold regions where the growth of plants completely ceases in winter, reproductive growth, which naturally belongs to short day period, comes delayed in the beginning of the long day period. Japanese red pine and black pine elongate their new shoots only in the first growing season and form their winter buds at the end of the season, while in *Cryptomeria* new shoots still continue elongation in the second growing season. The first growing season covers the long-day period (spring equinox—summer solstice—autumnal equinox) and second growing season in autumn covers the short-day period (autumnal equinox—winter solstice—spring equinox). The period of reproductive growth of Japanese two needled pine (meiosis of pollen mother cell—flowering—meiosis of embryo-sack mother cell) belongs to the former and that of *Cryptomeria* to the latter. In view of the above, it would be reasonable to call Japanese red pine and black pine long-day plants, and *Cryptomeria* short-day plants.

It has been clarified by the author (1957) that nitrogen plays important roles in the sex differentiation of Japanese red pine strobiles. The season of sex differentiation of the pine strobiles is in the middle or the end part of April when the absorption of nitrogen by root is becoming larger day by day. In this season, the meiosis of male flower occurs and, until this time, the sex of strobiles is not decisively fixed. Meiosis may be regarded as a atypical case of somatic cell division which is derived from the peculiar physiological cell condition, such as the lack of some important constituents. This presumption may be followed by the occurrence of the season of meiosis in the beginning or the end of the growing season. In July and August, over-rising of ground temperature and dryness hamper the physiological functions of tree roots, and, as the result of changes in the ratio of carbohydrate—nitrogen, meiosis takes place. It may be suggested, furthermore, that phosphate, an important constituent of nucleic scid, may be connected with meiosis. One indication of the lack of phosphate is discernible by the violet coloring of anthocyan just as in many plants.

The violet coloring in pine female strobiles which are being kept restrained from meiosis, may be caused by the short supply of phosphate, and occurrence of meiosis just prior to this time may be pressumed to be due to some unbalanced condition of nutriments. In female strobiles of *Cryptomeria*, coloring by anthocyan, sometimes, may be perceivable in November, the end of the second growing season. Coloring, caused by the lack of phosphate, is more in proportion to the ratio of phosphate to nitrogen than to absolute quantity. In experiments (Saito, 1957) on artificial sex transition from male strobile to female by pinching shoot, i. e., inhibition of meiosis in pollen mother cell, was more facilitated by spraying ammonium sulphate solution on young shoots and leaves, and become discernible by the coloring of anthocyan.

The details of the physiological process of above-mentioned phenomena are not clear, but it may be suggested that, in the spring growing season, there arises some abnormal condition in the ratio of phosphate to nitrogen due to the differences in the beginning time and increasing curve of absorption of above two nutriments, and beging accompanied by the production of anthocyan, sex transition follows, caused by the inhibition of meiosis. On the contrary, the occurrence of meiosis in embroy-sack mother cell and the differentiation of flower bud in the end of spring growing season, may be caused by unbalanced less taking-in of nitrogen and phosphate which is dependent upon decrease of root-function, though the condition is favorable to carbohydrate assimilation. Production of anthocyan does not follow in this case, but vigorous activity of peroxydase is perceivable in the region where meiosis is occurring. It has been ascertained that auxin level decreases and respiration rises in the season of meiosis and differentiation of flower bud in some plants. Accordingly, the lack of phosphate, connected with increasing consumption by respiration, is conceivable.

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