Morphological Observation on Viable and Nonviable Axillary Bud Formation in Non-branching Chrysanthemum ‘Iwanohakusen’

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Summary

Young, non-induced to flowering cuttings of the non-branching chrysanthemum \( [Dendranthema \times grandiflorum \ (Ramat.) \ Kitamura] \) ‘Iwanohakusen’ were exposed to 30/20 °C (day/night) to test whether the treatment inhibited differentiation of axillary buds from the shoot meristem. For comparison, comparable cuttings were grown at 20/15 °C (control). Axillary bud initiation on plants, grown at 30/20 °C, occurred, and the initials developed to a shell zone and a small mound of meristematic tissue in the leaf axils. However, they did not progress to the prophyll and leaf primordial stages as did the axillary buds of the control plants. Thus, the elevated temperature treatment did not affect the initiation of axillary buds, but it inhibited the meristem to differentiate further. Therefore, we consider that exposure to high temperature prevents differentiation of the prophyll and leaf primordium.

Key Words: nonviable axillary bud, \( Dendranthema \times grandiflorum \), Iwanohakusen, non-branching chrysanthemum.

Introduction

Recently non-branching (heat-sensitive type) of chrysanthemum (\( Dendranthema \times grandiflorum \) (Ramat.) Kitamura) became available for production of single-stem plants. Commercial chrysanthemum growers prefer this morphological characteristic because disbudding requires a great deal of labor. This phenotype produces stems without axillary buds and/or poor lateral shoot development when exposed to high temperature. Paust and Heins (1992) reported that a high day temperature alone was capable of causing poor lateral branching in ‘Powerhouse’. Schoelhorn et al. (1995) found that the number of viable lateral buds on ‘Improved Mefo’ exposed to 34/28 °C (day/night) was 40% of that on plants grown at 22/18 °C.

‘Iwanohakusen’ is one such cultivar grown for the summer cut flower market. Deguchi (2002), Kaneko and Morita (2002) and Matsumoto (2000) delved into the effects of temperature on the loss of lateral bud and branching potential, but their conclusion as to the loss of axillary bud viability is not clear. The objective of our study was to examine the morphological changes in the axillary meristem and determine at what step during its development does the inhibition of the axillary bud development occur as a result of high temperature exposure.

Materials and Methods

Sixty cutting 5 to 7 cm long of ‘Iwanohakusen’ were taken from stock plants' lateral shoots on 13 February 2001 and rooted in 7.5 cm pots (210 ml) in a soil: peat (4:1, v/v) potting mixture. The cuttings were placed in an air-conditioned glasshouse maintained at 20/12 °C (day/night) in which the natural photosynthetic photon flux was reduced by 62%. The temperature was programmed to increase from 12 °C (NT) to 20 °C (DT) from 4:00 to 6:00, where it remained until 18:00. The change to NT occurred from 18:00 to 20:00; it stayed at 12 °C for 8 hr. A night break with 5 \( \mu \text{mol} \cdot \text{m}^{-2} \cdot \text{sec}^{-1} \) irradiance from incandescent lamps at the plant level took place between 20:00 and 2:00 to interrupt the flower initiation process. Relative humidity was controlled 65%. After two weeks, plants were transplanted into 13.5 cm plastic pots (1250 ml) and administered 100 ml of liquid fertilizer (113 N, 19 P and 101 K mg·liter\(^{-1}\)) twice a week. High temperature treatment to prevent nodes from forming axillary buds, 20 plants were moved on 28 March to a glasshouse kept at 30/20 °C. On 27 April, the night break treatment was ended and the NT of the first glasshouse raised to 15 °C.

On 28 March, 5 plants were sampled to count the number of nodes that forms since the beginning of the high temperature treatment. The count of viable and aborted or nonviable axillary buds for each plants was taken at flowering time. A nonviable axillary bud is defined as one that lacks the development of a prophyll.

Received; November 19, 2002. Accepted; March 6, 2003.

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and leaf primordium. Shoot apices from five shoots at each temperature regime were sampled on 26 April, sectioned, and examined for axillary meristem development. Apices were fixed in formalin-acetic acid-alcohol solution, dehydrated with n-butyl alcohol, infiltrated and embedded in paraffin. Serial longitudinal sections (15 μm thick) that were made on a rotary microtome were affixed to slides, stained with fuchsin acid-fast green, and examined under a light microscope. Selected sections were photographed and pertinent structural features described.

Results and Discussion

An axil of the uppermost, unfold leaf on a cutting was designated as a first-order or standard node 1 (Fig. 1). For 30/20°C plants, the nonviable axillary buds started from 12.7. At flowering time, axillary branches, which formed flower clusters, were located at the upper three to five nodes. In contrast, plants grown continuously at 20/12°C had viable axillary buds at all leaf axils. Thus, the transfer to 30/20°C prevented the development of axillary buds. At the beginning of the high temperature treatment, the plants had already 19.8 nodes (Fig. 1) indicating that the nodes between 12.7 and 19.8, which had differentiated before high-temperature treatment, lacked axillary buds.

On the longitudinal sections of the shoot apices of control plants, axillary bud initiation and differentiation occurred, forming a shell zone, which delineated the residual meristem from the shoot meristem, at leaf primordium positions five to eight down from the shoot apex. A small mound of axillary meristem (Fig. 2A) formed at positions nine to 10, which proceeded to differentiate the initial pair of foliage leaf primordia at

![Fig. 1. Schematic drawing illustrating the location of nodes without axillary buds on 'Iwanohakusen' chrysanthemum plants grown under 30/20°C (day/night) and 20/12°C (control). Node 1 indicates the most upper unfold leaf at the time of cutting. Node number represents the mean of 12 individual plants.](image)

![Fig. 2. Longitudinal sections of axillary meristems in 'Iwanohakusen' chrysanthemum grown at 20/12°C (day/night) (A and B) and under 30/20°C (C and D). A, a small mound of meristematic cells; B, the initial pair of foliage leaf primordia; C, a shell zone (arrow); D, a small mound of metasomatic cells. I signifies a developing leaf. Bars = 0.1 mm](image)
position 11 (Fig. 2B). Treated plants underwent axillary bud initiation and differentiation to the shell zones (Fig. 2C) at positions five to 12 and small mounds (Fig. 2D) below position 13, but they did not proceed to the prophyl and leaf primordial stages.

Our morphological examinations revealed that axillary meristems were initiated in both treated and control plants to the point where small mounds of meristematic cells formed. The difference lies in the subsequent development of the two classes of buds. Whereas control plants developed axillary meristems that became leaf primordia, the treated plants did not. Thus, the high temperature treatment did not affect the axillary bud initiation but inhibited further differentiation and development. The results reveal that buds in some leaf axils that differentiated before the high temperature treatment subsequently became nonviable. We, therefore, conclude that exposure to high temperature blocks the differentiation of prophyl and leaf primordium.

Our results agree with those of Boonprakob et al. (1996), who reported both the normal and blind buds in the peach tree began as bud meristems, as evidenced by small mounds of meristematic cells in the leaf axils. Whereas the normal axillary buds develop into apical and prophyl formations, blind nodes do not. They concluded that blind node formation was a consequence of a lack of bud differentiation rather than a failure of bud initiation. In chrysanthemums, the high day temperature inhibited axillary bud initiation but did not affect the sprouting of pre-existing axillary buds in ‘Powerhouse’ (Faust and Heins, 1992). Schoellhorn et al. (2001) reported that the only mechanism for bud loss of ‘Improved Mefo’ was the differentiation of meristematic cells into nonmeristematic parenchyma tissue. We assume that there are different pathways to the loss of axillary bud viability in chrysanthemum.

**Literature Cited**


無側枝性キク‘岩の白扇’における
腋芽と無腋芽の形態観察

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**摘要**

無側枝性キク‘岩の白扇’の腋芽が形成されない腋芽の成立過程を明らかにするため、高温によって腋芽が形成されない節が出現する節の調査と、腋芽分裂組織の形態観察を行った。腋芽が形成されない腋芽は高温処理(30/20℃、昼/夜)前に関化していた腋芽から始まった。高温処理した植物体の腋芽分裂組織では、頁状帯および分裂組織の細胞からなる丘状の形態が観察された。しかしながら、対照区(20/12℃)でみられる前線および薬芽原基は観察されなかった。従って、30/20℃処理は腋芽分裂組織における前線および薬芽原基の分化の段階に影響し、主軸の頂端分裂組織における腋芽の発生開始には影響を及ぼさないと考えられる。