論文の内容の要旨

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Effects of pollination and crop load on fruit growth patterns of gynoecious type cucumbers

（受粉と着果負担が雌性系統キュウリの果実成長パターンに及ぼす影響）

Cucumber（*Cucumis sativus* L.）flowers are classified into three types, i.e, staminate （male）, pistillate （female）and hermaphrodite （perfect）flowers. Staminate and pistillate flowers are borne on different nodes. Although pistillate flowers are solitary at occasional nodes in many cultivars, the number of pistillate flowers per node varies from one to more than three, depending on the cultivar, i.e., mono-pistillate, di-pistillate and multi-pistillate type cultivars（one, two and three or more pistillate flowers per node, respectively）. On the other hand, the several staminate flowers are borne on one node. Generally, cucumber plants are monoecious cultivars which produce both staminate and pistillate flowers separately on the same plant. Some cultivars bear only pistillate flowers（gynoecious）or

staminate and hermaphrodite flowers on the same plant (andromonoecious). Furthermore, some cucumber cultivars are able to set fruit without pollination and fertilization (parthenocarpy). Parthenocarpy is a valuable trait, especially in gynoecious cultivars that produce only a few staminate flowers.

In Japan, cucumber growers invest much labor towards vine training and pest control because they grow monoecious cultivars with single pistillate flower per node for a long period. Production cost can be reduced, if a large number of cucumber fruits could be harvested within a short period, using multi-pistillate cultivars or gynoecious, parthenocarpic cultivars. However, in both multi-pistillate and gynoecious cultivars, fruits at the middle nodes stop growing after anthesis and some fruits abort possibly because of intense competition for assimilates among fruits.

Pollination is known to increase the concentration of endogenous phytohormones and stimulate cell division, resulting in increases in fruit set and fruit growth. However, the effects of pollination and crop load on fruit retention have not been well studied in relation to endogenous hormones and sink strength (cell number and cell size) in cucumber cultivars bearing many pistillate flowers simultaneously. Therefore, in this study, fruit growth patterns were compared among pollinated and non-pollinated fruits, in relation to endogenous hormones, cell division, cell enlargement as well as sugar metabolizing enzyme activity in gynoecious, parthenocarpic cultivars.

1. Effects of pollination and growing season on fruit abortion in multi-pistillate and gynoecious cultivars

The effects of pollination and the growing season on the number of pistillate flowers and the number of fruits with commercial size were investigated in '028' (multi-pistillate, monoecious type) and 'NK × AN8' (mono- or di-pistillate,

gynoecious, parthenocarpic type）cultivars, in summer 2004 and spring 2005. The ratio of the number of nodes with pistillate flowers（PF nodes）to that of total nodes was not different between spring and summer in either cultivar, but the number of pistillate flowers per PF nodes was lower in summer than in spring, especially in ‘028’. The fruit abortion rate was significantly reduced by pollination and was higher in summer than in spring in both cultivars. The number of harvested fruits in gynoecious, parthenocarpic cultivar, ‘NK × AN8’, was slightly lower in non-pollinated group than in pollinated group because it can bear much more pistillate flowers per plant in summer than in spring. On the other hand, the number of harvested fruits was much lower in summer in ‘028’ because it can bear almost the same number of pistillate flowers per plant in both seasons.

2. Effect of pollination on endogenous hormones, cell division and cell enlargement during fruit development

The number of cells, cell size, mitotic index, histone H4 gene expression, and concentrations of endogenous cytokinins and auxin were compared during the development of fruitlets among pollinated and non-pollinated groups, in order to clarify whether the effect of pollination on fruit retention in a gynoecious, parthenocarpic cucumber is related to an increase in endogenous phytohormones. Fresh weight was greater in the pollinated group than in non-pollinated group at 4–12 days after anthesis（DAA）in both winter and spring, and at 2–6 DAA in summer. Mitotic index increased from anthesis to 2 DAA and then decreased gradually in the pollinated group, but immediately decreased after anthesis in the non-pollinated group. Histone H4 gene in the pericarp zone was expressed more strongly during the period from pre-anthesis to 2 DAA in the pollinated group. Concentrations of zeatin（Z）, isopentenyladenine（iP）, and indole-3-acetic acid（IAA）were higher in the non-pollinated group than in pollinated group at 2 and 4 DAA. They peaked at 4 DAA in both pollinated and non-pollinated groups, whereas iP and IAA showed no distinct peaks in the pollinated group. These results indicate

that pollination stimulates cell division and hastens the start of cell elongation, but do not provide any evidence to support the idea that pollination activates cell division by stimulating the synthesis of cytokinins and auxin in cucumber fruits.

3. Effect of crop load on fruit growth and endogenous phytohormones

The effects of fruit load（fruits from nodes 9 to 14）and removal of these fruits at 4 or 8 DAA on the growth, cell number, cell size of fruit at node 15 as well as endogenous IAA, Z, zeatin riboside（ZR）, iP and isopentenyladenosine（iPR）concentrations were investigated in a gynoecious, parthenocarpic cucumber cv.

NK × AN8. Fruit fresh weight increased rapidly from anthesis to 4 DAA and reached commercial size（*ca.*100 g）at 6 DAA when only one fruit was allowed to grow（no fruit-load treatment）, while fruits showed little growth and finally aborted when fruits at nodes 9 – 14 were retained（fruit load treatment）. The fruit at node 15 restored growth and reached commercial size at 12 DAA when fruit load was removed at 4 DAA. IAA concentrations increased and reached its peak at 8 DAA, then decreased slightly at 12 DAA. Fruit removal decreased IAA concentrations. Z concentrations decreased close to zero in the fruit load treatment, but maintained rather high when fruit load was removed at 4 or 8 DAA. These results suggest that the high concentrations of IAA and low concentrations of Z cause fruit abortion in fruits which have ceased to grow for more than 10 days.

4. Sugar metabolizing enzyme activity in fruit and carbohydrate translocation

In order to clarify whether the activities of sucrose metabolizing enzymes were higher in active growing fruits than in fruits which stopped growing, acid invertase（AI）, neutral invertase（NI）and sucrose synthase（SS）activities in fruits were monitored during fruit development in defoliated and non-defoliated ‘NK × AN8’ cucumbers. The fruits attained commercial size at 14 DAA in the control plants（non-defoliation）, whereas in the defoliated plants, the fruits failed to reach

commercial size. When defoliation was carried out at 0, 2 and 4 DAA, fruit growth was markedly restricted and 40, 20 and 20% of the fruits aborted, respectively. Fruit abortion did not occur in the defoliation treatments at 6 and 8 DAA and in the non-defoliation treatment. In the non-defoliated plants, AI, NI and SS activities were high at 4 DAA at which fruit cells began to elongate, while no significant differences were observed among other dates. AI activity in the defoliated plants was slightly increased at 8 DAA, i.e. 2 days after defoliation at 6 DAA. Sucrose and oligosaccharide concentrations in exudates from cut surface of fruit peduncles increased from 2 to 6 DAA in the non-defoliated plants, while sucrose increased at 8 DAA, i.e. 2 days after defoliation at 6 DAA in the defoliated ones. These results suggest that an increase in AI stimulates sucrose import into fruits around 4 DAA, resulting in the prevention of fruit abortion in parthenocarpic cucumber.

In conclusion, gynoecious, parthenocarpic type cucumbers can be cultivated in order to achieve high yield within a short period. However, pollination is necessary to reduce fruit abortion in multi-pistillate or gynoecious cultivars, especially in summer. Pollination stimulates cell division and hastens cell enlargement, but does not necessarily increase endogenous auxin and cytokinins concentrations. It is possible that high IAA and low Z concentrations cause fruit abortion in fruits which have ceased to grow for more than 10 days.