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(Course of Applied plant Science)

液肥濃度と無機養分がキクの黄斑発生に及ぼす影響

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Effect of Nutrient Levels and Mineral Composition on the Occurrence of Yellow-leaf-spot in Chrysanthemum

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Yellow-leaf-spot, a physiological abnormality occurring in leaves of several chrysanthemum (*Chrysanthemum ×morifolium*) cultivars harvested from September to October, is a very serious problem in Japan, of which causes have not been well established. Water stress, high temperature, high irradiation or nutrient stresses are possible physiological factors which may lead to yellow-leaf-spot. In the present study, effects of nutrient levels and mineral composition on the occurrence of yellow-leaf-spot were investigated. 'Seikou-no-makoto' and 'Seikou-no-masaru' plants were grown in 5 nutrient solutions (N 0, 60, 120, 180, 240 ppm based on Enshi-shoho). In 'Seikou-no-masaru' no yellow-leaf-spot occurred. However, in 'Seikou-no-makoto', the nodal position with spotted leaves and rate of yellow-leaf-spot increased as nutrient levels increased. 'Seikou-no-makoto' plants were supplied with 6 different nutrient solutions containing 3 times N, P, K, Ca, Mg or Fe in 1/3 concentration of Enshi-shoho solution for 3 or 14 days. The nodal position with spotted leaves and rate of yellow-leaf-spot was not affected by mineral composition. The nodal position with spotted leaves and rate of yellow-leaf-spot increased with increasing days of application. Both cultivare were supplied with 7 different nutrient solutions with lacked N, P, K, Ca, Mg, Fe or only microelement (no mineral) in 1/2 Enshi-shoho solution for 10 days. In 'Seikou-no-masaru', no yellow-leaf-spot occurred. It occurred only in 'Seikou-no-makoto'. yellow-leaf-spot occurred in control, P, K, Ca, Mg, Fe deficiency and no mineral, but only slightly in all cases. These results suggest that the occurrence of yellow-leaf-spot was dependent on genotype, and that excessive or deficiency specific elemental mineral stress had no significant effect.

Key words : EC, Genotype, Nutrient deficiency, Nutrient excess, pH

Introduction

Chrysanthemum, with a volume of around 35% of Japan's total cut flower production, is the most intensively produced flower in Japan. However, it faces a problem of yellow-leaf-spot, thereby reducing the quality of cut flowers, posing a serious problem to the producers. Yellow-leaf-spot was initially associated in some cultivars with harvesting during high temperature seasons. In recent years, however, it has been occurring in many cultivars throughout the year, regardless of temperature at harvest. For example, this problem occurs in 'Jinba', which is the most widely produced cultivar of chrysanthemum and 'Seikou-no-makoto', which is popular for its large snow-white flower and has a high market value.

Yellow-leaf-spot has been reported in leaves of African violet (*Saintpaulia spp.*) where it is caused by chilling injury[1]. In chrysanthemum, its cause is thought to be an imbalance in environmental factors during growth such as high light intensity, high temperature[2], pH, high EC, water stress and nutrient stress[3] or a combination of some or all factors. Tanaka and Kokubo[4] reported that occurrence of yellow-leaf-spot was remarkable in a soil with a high concentration of phosphoric acid, and that the occurrence was a symptom of phosphate excess. This was further supported by the fact that there was reduced occurrence of yellow-leaf-spot when the experiment was repeated in a soil with high content of phosphoric acid after mixing with a sludge from the water purification process which is known to absorb phosphoric acid. However, we reported that yellow-leaf-spot varied with season and reduced

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during low temperature periods[5], making it implausible to conclude that phosphate excess was the only factor. While phosphate may be one cause of physiological disorders such as yellow-leaf-spot, it may be prudent to suggest that general nutrient excesses or deficiencies are the causes of yellow-leaf-spot in chrysanthemum.

In chrysanthemum, sensitivity to high nutrient concentration (high EC) varies greatly in lines and cultivars. Occurrence factor may be physiological disorder by high EC, including phosphate excess symptom. Further, physiological disorder is induced by specific nutrient deficiency in most plants. In most plants including chrysanthemum, magnesium and iron deficiency induce yellowing in leaf blade.

Thus, effect of nutrient levels and mineral composition on the occurrence of yellow-leaf-spot in chrysanthemum was investigated in this study.

Materials and Methods

Exp. 1. Effect of specific mineral nutrient excess on the occurrence of yellow-leaf-spot.

'Seikou-no-makoto' was planted in pots (0.75 L) filled with peat-mix (peat moss : sand = 3 : 1 v/v) on 26 May 2005. Night break was performed with incandescent lamp from 22 : 00 to 2 : 00. Treatment was started on 26 June. Based on 1/3 concentration of Enshi-shoho (N 80 ppm), 6 culture solutions with 3 times concentration of each mineral nutrient (N, P, K, Ca, Mg, Fe) and control (1/3 concentration of Enshi-shoho), were made and provided, if necessary 1–3 times per day for 3 or 14 days. Except during treatment period, complete culture solution (N 80 ppm) was provided. Potential of hydrogen of each culture solution was equal with control (about pH 5.7). After 60 days application started, the degree of yellow-leaf-spot was evaluated (0; No spots, 1; Very few, 2; Only leaf margin, 3; Leaf margin and blade, 4; Spread throughout).

Exp. 2. Effect of specific mineral nutrient deficiency on the occurrence of yellow-leaf-spot

'Seikou-no-makoto' and 'Seikou-no-masaru' were planted in pots (0.3 L) filled with peat-mix on 12 July 2002. Night break was performed same as Exp. 1. Plants were grown under a shade (transmission factor about 50%) from 18 July for 10 days. Treatment was started on 27 July. Based on 1/2 concentration of Enshi-shoho (N 120 ppm), 7 culture solutions with lacked each mineral nutrient (N, P, K, Ca, Mg, Fe), only microelement (no mineral) and control (1/2 concentration of Enshi-shoho), were made and provided, if necessary 1–3 times per day for 10 days. Except during treatment period, complete culture solution (N 120 ppm) was provided. Potential of hydrogen of each culture solution was equal with control (about pH 5.7). After 60 days application started, the degree of yellow-leaf-spot was evaluated.

Exp. 3. Effect of nutrient levels on the occurrence of yellow-leaf-spot

'Seikou-no-makoto' was planted in pots (0.75 L) filled with peat-mix on 27 November 2005. Night break was performed same as Exp. 1 and 2. Treatment was started on 26 December. Based on Enshi-shoho, 4 culture solutions (N 0, 60, 180, 240 ppm) and control (1/2 concentration of Enshi-shoho) were made and provided, if necessary 1–2 times per day for 14 days. Except during treatment period, the same concentration as control (N 120 ppm) was provided. Potential of hydrogen of each culture solution was equal with control (about pH 5.7). After 60 days application started, the degree of yellow-leaf-spot was evaluated.

Results

Exp. 1. Effect of specific mineral nutrient excess on the occurrence of yellow-leaf-spot.

After 30 days of application, stem length was slightly shorter in control than in the other treatments. Node number reduced in Fe excess. After 60 days of application, no effect of treatments on growth was observed except for the short stem length in control. In all the treatments no injury due to mineral excess was observed.

The degree of yellow-leaf-spot increased where the plants were treated for 14 days in comparison with the 3 days treatment. There was a similar trend in the effect of specific nutrient excess on yellow-leaf-spot occurrence in both 3 and 14 days treatment. Therefore, only the results of 14 days treatment are shown. The degree of yellow-leaf-spot was slightly lower in control than in nutrient excess treatment. However, no significant difference from specific mineral nutrient excess was observed in short term on the occurrence of yellow-leaf-spot (Fig. 1).

Exp. 2. Effect of specific mineral nutrient deficiency on the occurrence of yellow-leaf-spot

After application there was yellowing thought to be a symptom of N deficiency, but no effect of treatment on stem length or node number was observed both at the start of application started and after 60 days.

In 'Seikou-no-masaru', no yellow-leaf-spot occurred. It occurred only in 'Seikou-no-makoto'. Therefore the results of 'Seikou-no-makoto' are shown (Fig. 2). Yellow-leaf-spot occurred in control, P, K, Ca, Mg and Fe deficiency, but only slightly in all cases.

Exp. 3. Effect of nutrient levels on the occurrence of yellow-leaf-spot

After 30 days of application, there was no effect on

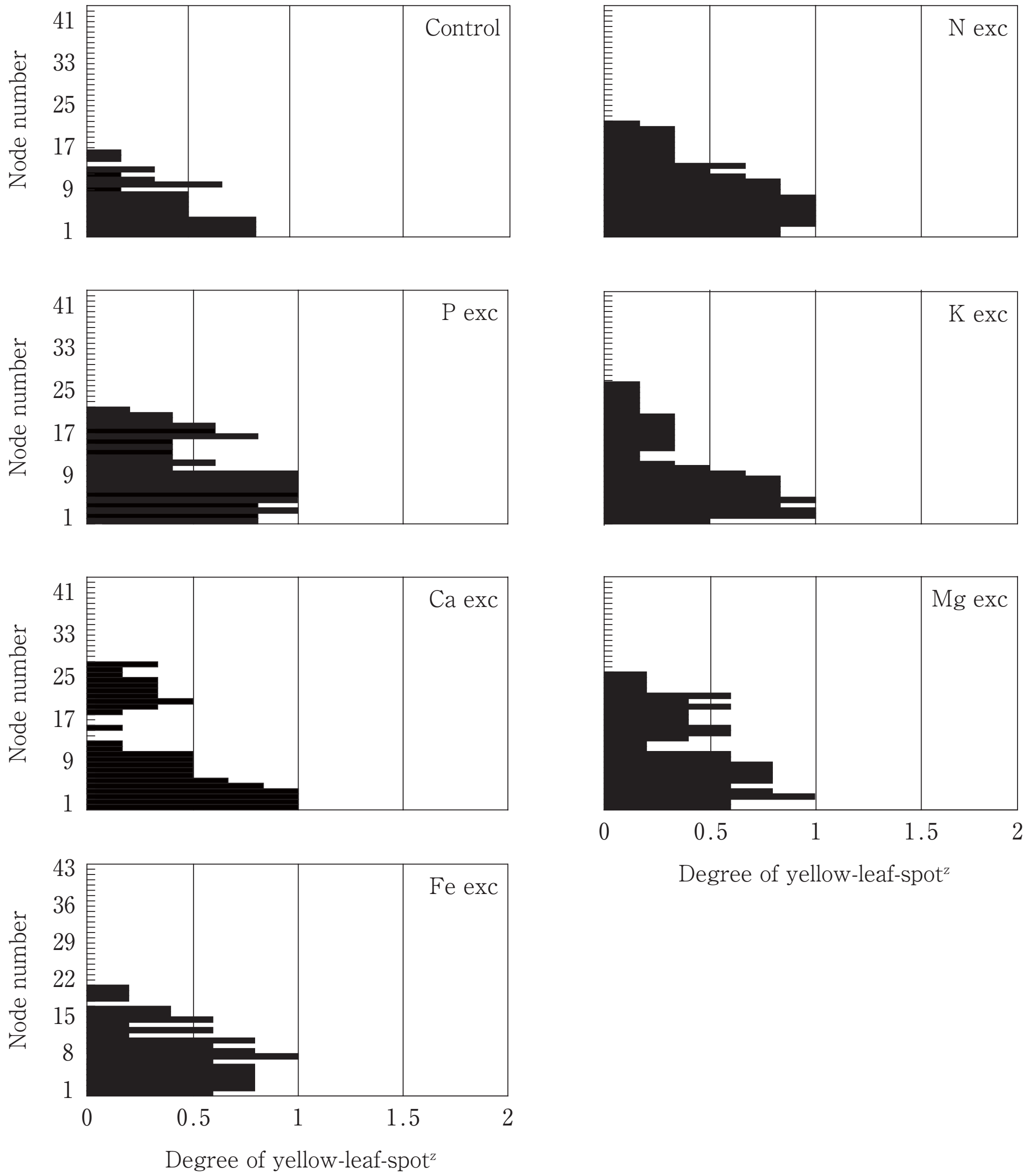

Fig. 1 Effect of excessive (exc) mineral nutrient on the occurrence of yellow-leaf-spot in 'Seikou-no-makoto'.
Plants were supplied with 6 different nutrient solutions containing 3 times N, P, K, Ca, Mg or Fe in 1/3 Enshi-shoho solution for 14 days. ^zDegree of yellow-leaf-spot; 0; No spots, 1; Very few, 2; Only leaf margin, 3; Leaf margin and blade, 4; Spread throughout.

growth. However, total plant fresh weight and leaf weight decreased in both 60 ppm and 0 ppm. In addition, stem length also decreased in 0 ppm. Yellowing of leaf and dark purpling of lower part of stem thought to be nutrient deficiency occurred in 0 ppm. Further, almost leaves in medium and low concentration died after 60 days of application.

As culture solution concentration increased, degree of yellow-leaf-spot increased. There was no effect of nutrient level on occurrence range of yellow-leaf-spot (Fig. 3). Occurrence of yellow-leaf-spot couldn't be determined in 0 ppm, due to yellowing and death of leaves.

Discussion

Tanaka and Kokubo[4] reported that phosphate excess was a main factor in occurrence of yellow-leaf-spot, because yellow-leaf-spot increased in soil with a high concentration of phosphoric acid. However, yellow-leaf-spot occurred in all treatments with specific nutrient excess in this study. Furthermore, the degree of occurrence didn't differ with treatments, when plants were supplied with a culture solution with 3 times concentration of each specific mineral (N, P, K, Ca, Mg, Fe) for 3 or 14 days. The degree of occurrence increased as treatment period increased. There were no significant

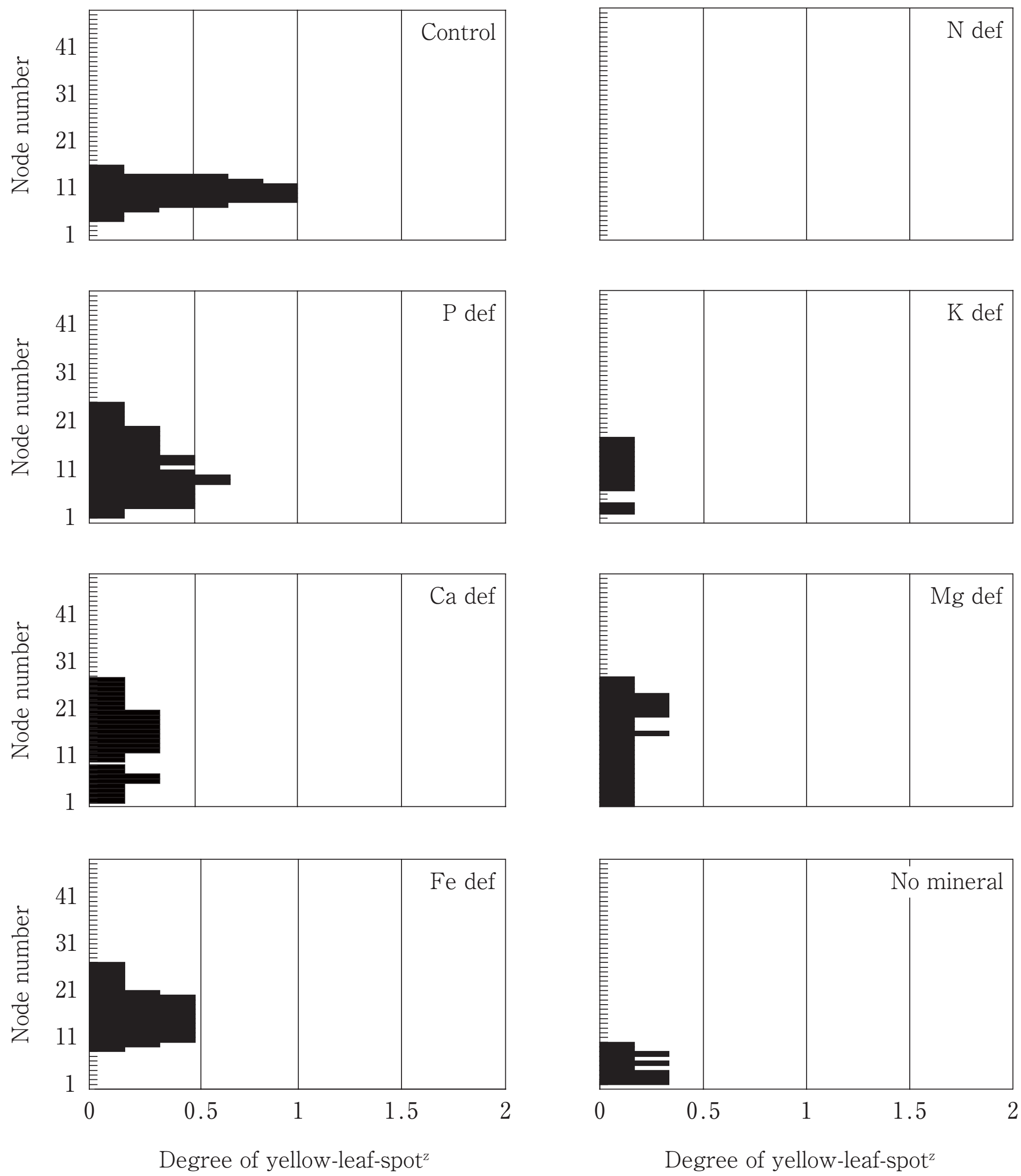

Fig. 2 Effect of deficient (def) mineral nutrient on the occurrence of yellow-leaf-spot in 'Seikou-no-makoto'.
Plants were supplied with 7 different nutrient solutions without N, P, K, Ca, Mg, Fe or macro mineral (no mineral) in 1/2 Enshi-shoho solution for 10 days. ^Z See Fig. 1.

differences in the occurrence of yellow-leaf-spot with specific nutrient concentration supplied over 3 or 14 day period (Fig. 1). Therefore, it seems implausible to conclude that phosphate excess was the only factor. In addition, yellow-leaf-spot occurred in both phosphate deficiency and phosphate excess (Fig. 1 and Fig. 2), and varied with season[5]. However pH decreases in soil with increase in concentration of phosphoric acid, and this could potentially affect absorption nutrient. There are many reports of pH changes when nutrient concentration changed in culture solution[6]. Therefore, we made culture solution of the same pH. However, pH was lower, as phosphate increased, in Tanaka and Kokubo's experiment. It is possible that low pH induced differences in absorption of nutrient and caused yellow-leaf-spot to occur. In future, we will have to examine the effect of pH on the occurrence of yellow-leaf-spot.

Physiological disorder, such as chlorosis and leaf-spot occur when a mineral nutrient is deficient in most plants. In particular, leaf blade is yellow when magnesium and iron are deficient[7] and a symptom that resembls leaf-spot appears. Occurrence of yellow-leaf-spot wasn't different when mineral nutrient had been deficient for 10 days in this study (Fig. 2). In case of N deficiency, no yellow-leaf-spot occurred. Therefore, we find it hard to conclude that yellow-leaf-spot related to

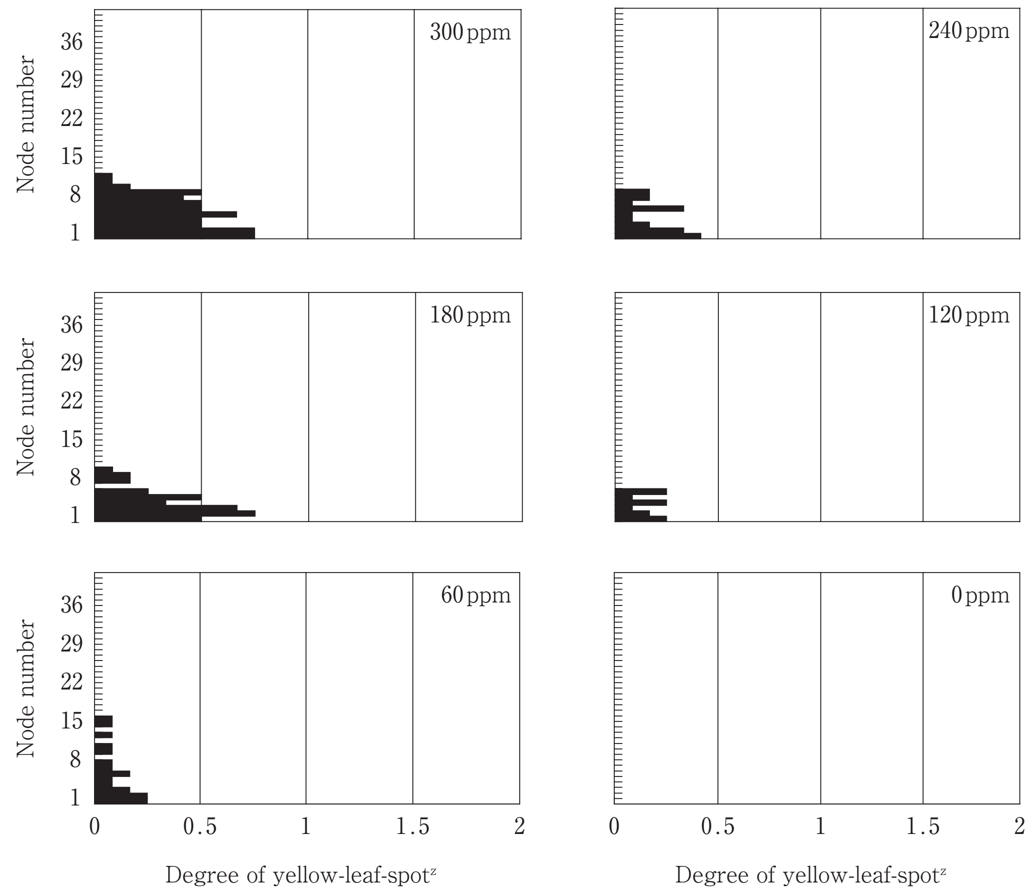

Fig. 3 Effect of nutrient level on the occurrence of yellow-leaf-spot in 'Seikou-no-makoto'.
Plants were supplied with 6 different nutrient solution (0, 60, 120, 180, 240, 300 ppm N based on Enshi-shoho solution) for 14 days. ^{Z}See Fig. 1.

specific mineral nutrient deficiency or excess. In production fields, low and high pH induces inhibition of nutrient absorption, which increase occurrence of yellow-leaf-spot.

In most plants, nutrient excess and high EC affect nutrient absorption. Horita et al.[8] reported that sensitivity to high nutrient concentration (high EC) varies greatly with strains and cultivars in chrysanthemum. In this study, yellow-leaf-spot increased, as total nutrient concentration increased. We hypothesize that root sensitivity to pH and EC may be responsible for occurrence of yellow-leaf-spot in weak cultivars.

As we have reported[2,9], no yellow-leaf-spot occurred in 'Seikou-no-masaru'. Further, Goto et al.[10] reported a variation in lines, in reduction of occurrence of yellow-leaf-spot, in 'Seikou-no-makoto' mutants induced by gamma ray irradiation. These results suggest that the occurrence of yellow-leaf-spot is dependent on genotype.

Goto et al.[5] investigated occurrence of yellow-leaf-spot throughout the year, and reported that its occurrence increased under high temperature and high light intensity and decreased under low temperature. And they reported that yellow-leaf-spot increased when environmental conditions, especially, temperature and light, changed. Under high temperature and light intensity, oxygen is reduced to reactive oxygen by the energy of excess of light absorption[11]. This reactive oxygen induces sunburn and chlorosis[12]. Yellow-leaf-spot may be induced by reactive oxygen. A detailed examination will be necessary in future.

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液肥濃度と無機養分がキクの黄斑発生に及ぼす影響

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9月から10月収穫の作型のキク（*Chrysanthemum*×*morifolium*）の葉身で発生する黄斑は水ストレス，高温，強日射，養分ストレスが発生要因として考えられている．本実験では無機養分の濃度，バランスが黄斑の発生に及ぼす影響を調査した．'精興の誠' を5種類の濃度の液肥（園試処方N 0，60，120，180，240，300ppm）で栽培した場合，液肥濃度が高くなるにつれ，黄斑が発生する範囲，程度共に増大する傾向が見られた．'精興の誠' と '精興の勝' に園試処方1/3濃度を基準とし，N，P，K，Ca，Mg，Fe それぞれを基準の3倍になるように作成した液肥を3または14日間与えた場合，'精興の勝' では黄斑発生は見られなかった．'精興の誠' では黄斑発生は見られたが，発生範囲，発生度ともに処理の影響は見られなかった．また，それぞれの無機養分を欠如させた液肥を作成し10日間与えた場合も黄斑発生に影響は見られなかった．これらの結果から，黄斑発生には遺伝的要因が関与しており，特定の無機養分の過不足により引き起こされるものではないと考えられた．

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