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Control of Spiking in *Phalaenopis* by Application of Mineral Salts and Plant Growth Regulators

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Abstract

$(NH_4)_2SO_4$ and NH_4NO_3 were the resources of nitrogen that inhibits spiking of *Phalaenopisis*. Plants, which received 5 me · l^{-1} of $(NH_4)_2SO_4$ or NH_4NO_3 weekly were delayed spiking about one month. K_2SO_4 and KNO_3 did not inhibit spiking and flower development of *Phalaenopisis*. The number of flowers in plants, which received NH_4-N decreased slightly compare to the control.

Plant growth regulators (PGRs) were other resources to control spiking and flower induction of *Phalaenopisis*. Naphthalene acetic acid (NAA) affected the reproductive growth of *Phalaenopisis* depending on the concentration that applied to the plant. NAA sodium salt, 1000ppm delayed spiking about one month. However, Benzyl adenine (BA) showed no clear effects on spiking.

Drop of flower buds showed higher negative correlation with night relative humidity.

Introduction

Reproductive growth of *Phalaenopisis* is induced by low temperature. Temperature under 25°C is needed for plants to induce inflorescences and flower buds, and the higher temperature than 25°C inhibits reproductive growth (Ishida and Sakanishi., 1977). Therefore, *Phalaenopisis* plants produce flowers in winter. In order to control the flower induction in winter, temperature control by heating is required. But heating cost is becoming higher and spiking control by heating becomes costly. To reduce the production cost, an alternative method with low heating cost is required.

Spiking of *Phalaenopsis* was affected by some factors (Ichihashi, 2003). It was suggested that spiking of *Phalaenopisis* could be controlled by application of NH_4-N under lower temperature (Horio and Ichihashi, 2003). It is practical and rather easy practice to control spiking by fertilization. Another alternatives are control by PGRs. Although PGRs seem to have some potential to affect spiking, few papers described the control by them.

In this research, we reconfirmed the effects of nitrogen application on spiking and potentiality of PGRs on spiking control were investigated.

Materials and Methods

Clone plants of *Phalaenopisis* (Kinu White Coffee x Kinu White Beer) with average leaf number 5.57 and which imported from Indonesia were used as plant materials. The plants had been potted in 10 cm-diameter plastic pots with sphagnum moss. Eight potted plants were arranged in a plastic tray and cultivated in greenhouse from August 11, 2004. All pots were poured 200 ml of fungicide and sprayed bactericides. Plants were kept for the first 1 week under 90% shaded condition and then changed to 78% shaded condition. Heating was started from November 3 and shading was changed to 60%. The temperature during experiment was between 10°C and 40°C and humidity was between 8% and 100% (Fig.1). In the experiments, each treatment were replicated 24 (3 trays). The data were recorded weekly and the position of each tray was changed.

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Experiment 1. In this experiment, each plant was applied weekly 300ml of (1) tap water (control), (2) 5 me · l^{-1} of K_2SO_4 solution, (3) 5 me · l^{-1} of KNO_3 solution, (4) 5 me · l^{-1} of $(NH_4)_2SO_4$, and (5) 5 me · l^{-1} of NH_4NO_3 solution from August 16, 2004 to April 12, 2005. These solution were prepared by dissolving 4.35g of K_2SO_4, 5.05g of KNO_3, 3.38g of $(NH_4)_2SO_4$, and 4.0g of NH_4NO_3 into 10 liters of tap water respectively.

Experiment 2. NAA solution, 1, 10, 100, and 1000 ppm were prepared by dissolving NAA sodium salt into deionized distilled water. BA, 100, and 1000 ppm were also prepared by dissolving BA into ethanol first and then adjusted concentrations by adding deionized distilled water. Stock solutions were kept in a refrigerator. In BA stock solutions, precipitation of BA crystals were observed. Before application it was shaken well and used..

Two hundred ml (400 ml per plant) of each solution or deionized distilled water (control) was applied to the axils of the 3rd and 4th leaf of each plant at August 17, September 22, and October 21. All plants in this experiment were applied weekly with 300ml of tap water.

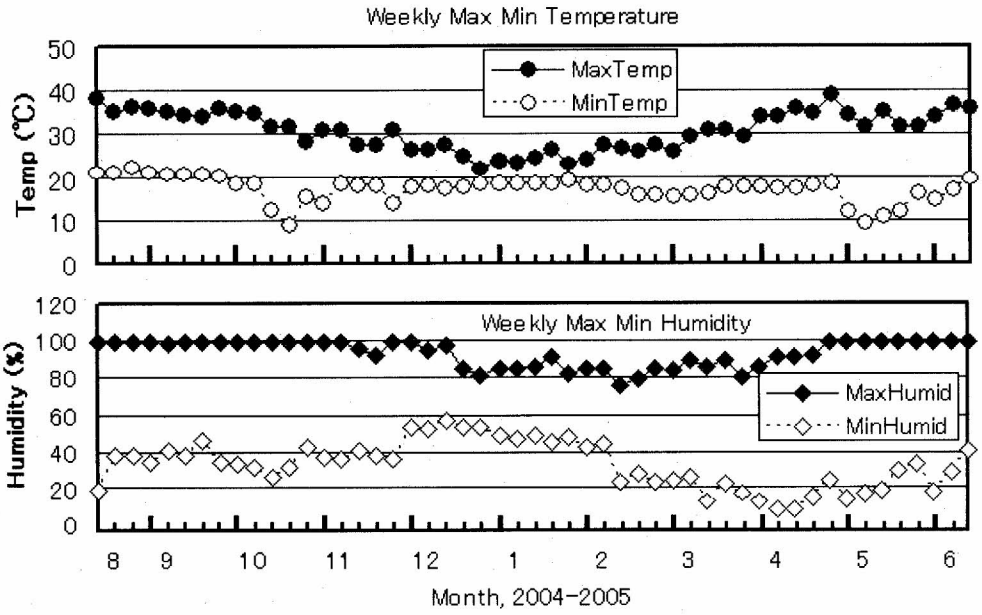

Fig. 1. Maximum and minimum temperature and relative humidity during experiments.

Results

Experiment 1. Development of inflorescence is shown in Fig. 2. Primary spiking started after October 12. $(NH_4)_2SO_4$ application delayed spiking a little. Start of primary spiking was delayed about 4 weeks by NH_4NO_3 application. Spiking of primary inflorescence was inhibited significantly at November 9 by NH_4NO_3 and $(NH_4)_2SO_4$ application (Table 1). Spiking of secondary inflorescence started after October 26 in K_2SO_4 application first fol-

Table 1. Effects of mineral salts on *Phalaenopsis* spiking.

Treatments	Percent of spiking			
	9-Nov-05		18-Jan-05	
	Primary	Secondary	Primary	Secondary
Control	69.6^{a*}	0.0^{b}	100^{a}	0.0^{b}
K_2SO_4	82.6^{a}	8.7^{a}	95.7^{a}	21.7^{ab}
KNO_3	58.3^{a}	0.0^{b}	91.7^{a}	37.5^{a}
$(NH_4)_2SO_4$	17.4^{b}	0.0^{b}	78.3^{a}	17.4^{ab}
NH_4NO_3	0^{b}	0.0^{b}	87.5^{a}	8.3^{ab}

*Different letter within columns represent significant difference by Duncan's multiple range test (P<0.05).

Table 2. Effects of plant growth regulator on *Phalaenopsis* spiking.

Treatments	Percent of spiking			
	9-Nov-05		18-Jan-05	
	Primary	Secondary	Primary	Secondary
Control	68.2^{a}	4.5^{a}	95.5^{ab}	27.3^{a}
NAA 1ppm	65.2^{a}	0^{a}	95.7^{a}	8.7^{ab}
NAA 10ppm	70^{a}	0^{a}	100^{a}	4.3^{ab}
NAA 100ppm	35^{b}	0^{a}	95.7^{a}	13.0^{ab}
NAA1000ppm	0^{c}	0^{a}	73.9^{b}	0.0^{b}
BA 100ppm	78^{a}	4.3^{a}	95.7^{a}	26.1^{a}
BA 1000ppm	56.6^{a}	4.3^{a}	73.9^{b}	17.4^{ab}

*Different letter within columns represent significant difference by Duncan's multiple range test (P<0.05).

lowed by KNO_3, NH_4NO_3 and $(NH_4)_2SO_4$ treatments. No secondary inflorescence was developed in control.

Number of flower buds produced in each inflorescence differed among treatments and less in $(NH_4)_2SO_4$ and NH_4NO_3 treatments (Fig.3a). Flower bud drop was observed in all treatments and significantly high in plants which received KNO_3 (Fig.3b). The flower longevity was shorter in plants received KNO_3 (Fig. 3c).

Experiment 2. NAA inhibited spiking depending on its concentration and higher concentration inhibited spiking well. One thousand ppm of NAA delayed spiking more than one month (Fig. 2b). The inhibitory effects of NAA were significant depending on the concentrations (Table 2).

Number of flower buds differed among treatments and less in plants which received 1000 ppm NAA and 1000 ppm BA (Fig.4a). Flower bud drop was observed in all treatments but no significant difference was observed (Fig.4b).

High concentration of NAA extended flower longevity, but high concentration of BA shortened flower longevity (Fig. 4c).

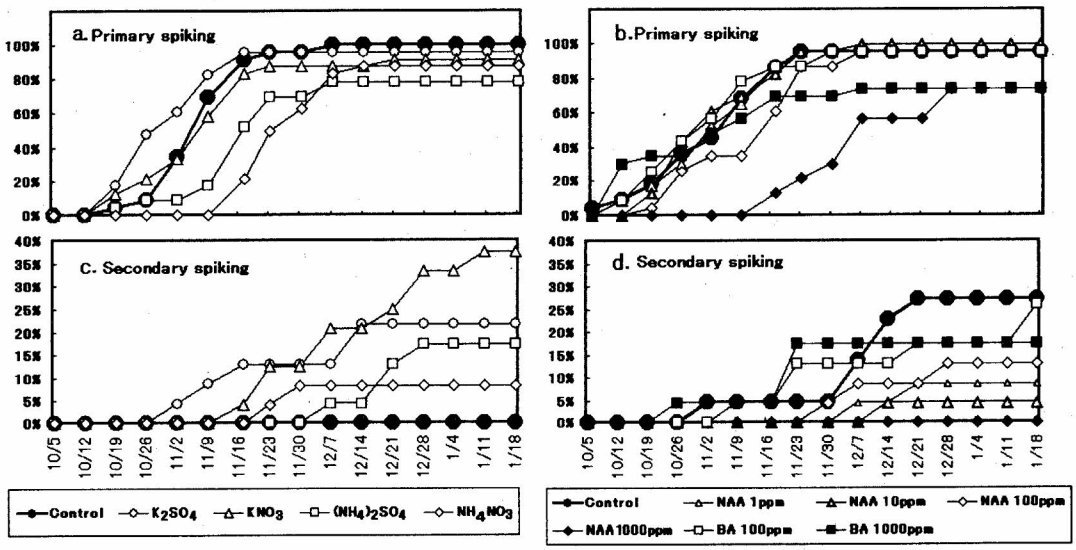

Fig. 2. Effects of mineral salts and plant growth regulator on *Phalaenopsis* spiking.

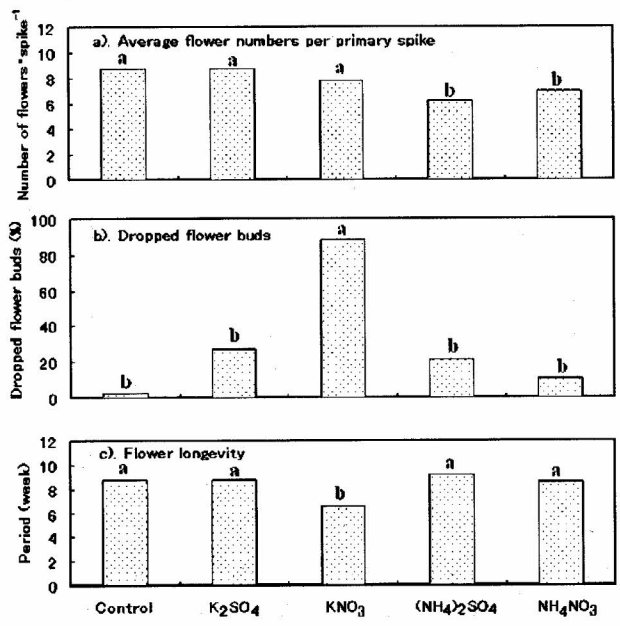

Fig. 3. Effects of mineral salts application on flowering.
* Different letter above bars represent significant difference by Duncan's multiple range test ($P<0.05$).

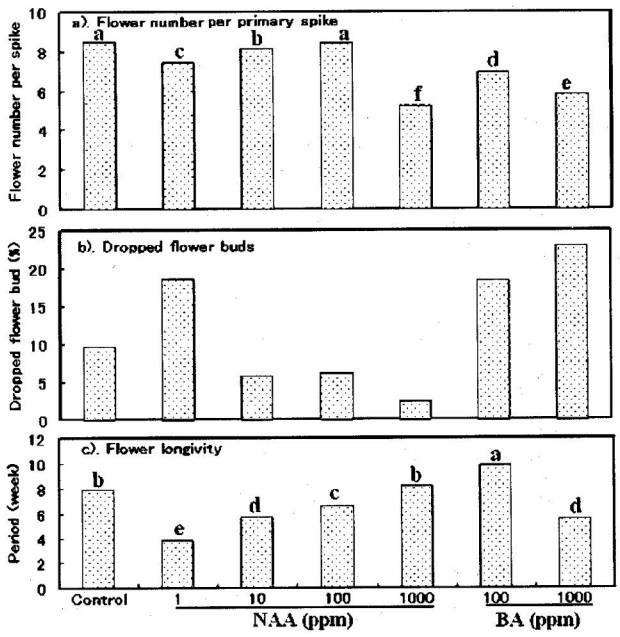

Fig. 4. Effects of mineral salts application on flowering.
* Different letter above bars represent significant difference by Duncan's multiple range test ($P<0.05$).

Discussions

The main interest of this investigation was inhibition of spiking by methods other than temperature control. Inhibitory effects of nitrogen on spiking have already shown (Ichihashi, 2003). Among nitrogen, inhibitory effects were specific to NH_4-N and non specific to NO_3-N (Horio and Ichihashi, 2003). In this experiment, inhibitory effects of NH_4-N and no inhibitory effects of NO_3-N on spiking were confirmed again. However, an inhibitory effect of NH_4-N was not long lasting and seemed to be easy canceling. Because spiking could not be inhibited more than one month. To make our method much practical, continuing inhibitory effects on spiking are required.

Applications of PGRs are the other choice to control spiking. Although effects of GA_3 on spiking have investigated, no inhibitory effect was known (Chen et al., 1994). Effects of NAA and BA are not clear yet. Spiking is a phenomenon caused by a decline of apical dominance. NAA and BA are the well known PGRs to modify apical dominance. Process of spiking seems to have close relations to apical dominance. In this experiment, NAA application to plant axils suppressed spiking and it is reasonable. BA and NAA supposed to affect on apical dominance antagonistically. However, BA showed no clear effects on spiking. Solubility of BA may be another reason of unexpected results. Solubility of BA was not high and precipitation was observed in stock solutions. This might be the reason that BA was not effective.

Both NAA and NH_4NO_3 affected spiking inhibitory but these chemicals are not homologous. It suggests that process of spiking undergo physiological processes where both chemicals affect inhibitory. Much research is required to clarify the effects of nitrogen and PGRs on spiking.

To attain much longer inhibition of spiking under lower temperature, simultaneous application of NH_4-N and NAA may be effective. Application of both NH_4NO_3 and NAA is the next step to be investigated. But much investigation is required to establish a stable and reliable method to control spiking by application of chemicals in *Phalaenopsis*.

Flower longevity is one of the most important characteristics of *Phalaenopsis* flower production. In this experiment flower buds dropped and early flower defoliation were observed in all treatments, especially in the plants which received KNO_3 (Fig. 3b). The inhibitory effects of nitrogen application on flower longevity have been indicated (Ichihashi, 2003). Nitrogen application affected flower stalk texture and became weaker. Application of KNO_3 might affect on flower texture and decreased flower longevity. To confirm the effects of KNO_3, much experiment is required.

The flower bud drop might be caused also by low humidity, because higher negative correlations between night humilities and number of flower bud drop were observed (Fig.5). Higher night humidity is an important

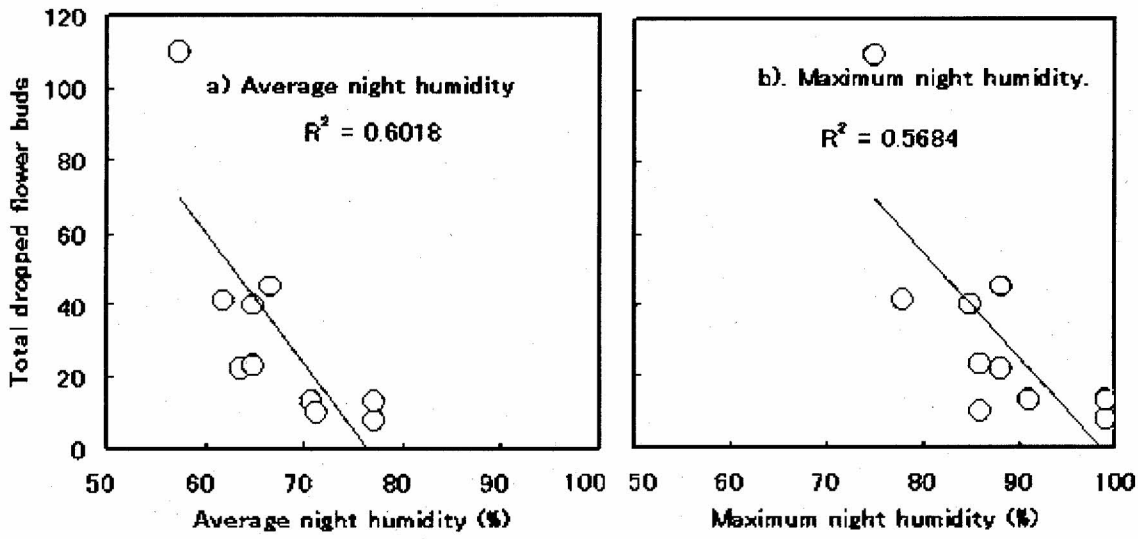

Fig. 5. Correlation between flower bud drop and humidity.
Total dropped flower bud number of all treatments in each week and relative humidity of the week were analyzed.

factor for the healthy development of flower buds.

Mechanical stress by the change of pot position, mineral salts application and watering may also be the cause of flower buds defoliation.

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無機塩と植物生長調節剤施用による花序発生の制御

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摘要

$(NH_4)_2SO_4$ と NH_4NO_3 はファレノプシスの花序発生を抑制した。5 me・l^{-1} の $(NH_4)_2SO_4$ あるいは NH_4NO_3 を毎週施用することによって花序の発生はおおよそ1ヶ月抑制された。K_2SO_4 と KNO_3 は花序の発生と開花を抑制しなかった。NH_4-N を施用した株では小花数が多少減った。

植物生長調節剤(PGRs) よってのファレノプシスの花序と花蕾の発生が抑制された。ナフタレン酢酸(NAA) の施用濃度によっても生殖生長は影響された。1000ppm のNAAナトリュウム塩の施用によって花序の発生はおおよそ1ヶ月遅延した。しかしベンジルアデニン(BA)の施用は花序の発生に影響しなかった。

花蕾の落下と夜間の湿度の間には高い負の相関が見られた。

(平成17年9月16日受理)