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Effects of Uniconazole Treatment on the Growth and Flowering of Potted *Chrysanthemum indicum* L.

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ABSTRACT This study was carried out to investigate the effects of uniconazole treatment on the growth and flowering of potted *Chrysanthemum indicum* L. for high quality pot plant production. Uniconazole was drenched at 0.05, 0.01, or 0.15 mg a.i./pot at 14 days after planting (DAP) of rooted cuttings. Simultaneously the short-day treatment (SDT) and pinching were adapted. The same amount of uniconazole (0.05 mg a.i./pot) was spilt drenched at once, twice, and three times, respectively, at 1 week interval. Uniconazole markedly reduced plant height, branch length, and stem diameter. Plant height was reduced linearly with increasing uniconazole concentration at 0.05, 0.01, or 0.15 mg a.i./pot up-to 41.6%, 52.5%, and 58.5%, respectively. In 0.05 mg a.i./pot, the number of branches greatly increased and plant height of 22.6 cm was adequate for pot plant. However, higher concentrations (0.10, 0.15 mg a.i.) were not suitable for production of high quality pot plant (17.0, 14.8 cm, respectively). Pinching and SDT decreased the number of days to visible bud, while uniconazole treatments delayed days to visible bud by 5-9 days compared with pinching and SDT. Number of visible buds was highest at 0.05 mg a.i./pot uniconazole treatment. However, flower diameter was decreased by uniconazole treatment, resulting in compact form. Number of stomata was increased by uniconazole treatment. The length of vascular tissues of uniconazole-treated plants (11.2 μm) was smaller than that of non-treated plants (15.0 μm), and the size of xylem vessel was also decreased. Uniconazole treatment at 0.05 mg a.i./pot at 14 DAP with pinching and SDT were recommended for pot plant production of *C. indicum* L.

Additional key words: chlorophyll content, plant growth regulator, plant height, pot flowering plant

Introduction

The species of *Chrysanthemum indicum*, *C. boreale*, and *C. zawadskii* are distributed over the country in Korea. They have been regarded as the putative parent of cultivated chrysanthemum and have a disease tolerance. Thus, it is very important to investigate the growth habit, cultural method, and so on. However, studies were conducted mostly on their morphological characteristics, distribution, or classification. *C. indicum* has an optimum morphological characteristics for pot plants and it is very important to control plant height well suitable to the container size in pot culture. Thus, it is necessary to determine optimum methods to obtain a desirable plant form for pot plant production. However, there has been a few available information for *C. indicum* on such as flowering control by day length and plant height control by plant growth regulators. The objective of this study was to investigate the effects of uniconazole treatment in relation to pinching and SDT on the growth and flowering of *C. indicum*.

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Materials and Methods

The plant materials used in this study was *C. indicum* collected from the Crops Experiment Station, RDA located in Suwon. Uniconazole was drenched at 0.05, 0.01, or 0.15 mg a.i. in 75 mL of water per pot at 14 DAP. Simultaneously, SDT and pinching were begun. Plants for control plants were all drenched with 75 mL of water per pot. The same amount of uniconazole was spilt drenched at 0.05 mg a.i./pot once, twice, and three times at 1-week interval to be compared with single application. Short day treatment was provided by covering black polyethylene film (0.05 mm) over plants from 17:00 to 09:00 for 65 days.

Growth characteristics

Growth data collected at the end of all treatments included plant height (from medium surface to the top of the plant), total

number of branches (sum of all branches), fresh weights and dry weights (after 72 hr at 60℃ in a forced-air oven) of shoots, flowers, and roots (hand-washed from media), stem diameter, and leaf area (LI-COR 3000 Leaf Area Meter). Time to visible bud was defined as the number of days from potting until a plant had three flower buds. All data were subjected to analysis of variance using the general linear model (GLM) procedure of SAS.

Chlorophyll content

1 cm^2 disc was collected from each of five fully expanded leaves from each plant. Leaf disks were removed from the center portion of a leaf from either side of the midvein, weighed (fresh weight), placed in glass vials (five leaf disks per plant per vial) to which 10 mL absolute methanol was added, and stored in the dark at ambient temperature for 24 hr, and then extracted the chlorophyll for spectrophotometric analysis (Moran and Porath, 1980). Absorbance was measured with a spectrophotometer (UV-1606, Shimadzu, Japan) at 665 and 649 nm on a 3 mL aliquot of the chlorophyll extract. Total chlorophyll content was calculated as $\mu g \cdot g^{-1}$ of leaf fresh weight using equations developed by Moran (1982).

Size and number of stomata

Five fully expanded, mature leaves (fourth visible node from the apex of stem) were selected from each of five plants which were treated with varying concentration of uniconazole. Samples were painted with transparent manicure to imprint the stomata for microscopic examination (Axioskop 50, Zeiss, Japan, 200×, 400×).

Xylem size of Stem

Segments were fixed in formalin-acetic acid-ethanol (FAA) for 24 hr, dehydrated with absolute ethanol for 9 hr, and infiltrated with paraffin at 57-60℃ drying oven for 48 hr. The stem was embedded with paraffin and sectioned with microtome. The specimen was deparaffined with xylene and stained with safranin, and examined with a microscope (Axioskop 50, Zeiss, Japan, 40×, 100×).

Results and Discussion

Growth and flowering of potted *C. indicum* were influenced by pinching, SDT and uniconazole treatments. Pinching and SDT decreased plant height. However, branch length and the number of leaves were increased. Uniconazole suppressed plant height, decreased branch length and stem diameter significantly, but the highest number of branches was achieved with 0.05 mg a.i./pot uniconazole drenched. Plant height was decreased with increasing uniconazole concentration at 0.05, 0.10, or 0.15 mg a.i./pot by 41.6%, 52.5%, and 58.5%, respectively (Table 1). Plant height of 22.6 cm was well matched with 18cm-pot when the uniconazole drench concentration was 0.05 mg a.i./pot, but higher concentrations (0.10, 0.15 mg a.i./pot) were not adequate to maintain proper plant height, thus resulting in short plants of 17.0 cm and 14.8 cm. Wang and Gregg (1989, 1990) reported that uniconazole was very effective in suppressing shoot elongation by inhibiting gibberellin biosynthesis and limiting the rate of leaf production and leaf size in *Hibiscus* 'Fane Cowl'. The efficacy of uniconazole was markedly visualized from 20 DAT.

While T/R ratio was slightly decreased at 0.05 mg a.i./pot

Table 1. Effects of concentrations of uniconazole drenching[z] on the growth of *C. indicum* at 80 days after planting.

Treatment			Plant height (cm)	Stem diameter (cm)	No. of branches (ea)	Branch length (cm)	No. of leaves (ea)	Leaf area per plant (cm^2)
Pinch-ing	Short-day	Uniconazole conc. (mg a.i./pot)						
-[y]	-		50.90 a[v]	0.74 ab	12.6 bc	23.1 b	105.0 b	1,557.6 ab
+[x]	-		41.40 b	0.79 a	19.4 b	32.5 a	128.7 a	1,866.2 a
+	+	0.00	35.80 c	0.70 b	43.2 a	30.6 a	135.0 a	1,413.6 b
+	+	0.05	20.90 de	0.55 de	47.0 a	17.0 c	89.3 b	1,131.3 bc
+	+	0.10	17.00 f	0.49 d	19.4 bc	12.2 d	79.3 b	779.1 c
+	+	0.15	14.84 f	0.46 d	14.0 bc	9.2 d	86.7 b	761.8 c
+	+	0.05×1[w]	22.64 d	0.61 c	42.2 a	17.1 c	89.7 b	965.8 c
+	+	0.05×2	18.08 ef	0.50 d	12.6 bc	12.3 d	86.3 b	928.7 c
+	+	0.05×3	16.04 f	0.46 d	12.0 bc	10.6 d	88.7 b	892.6 c

[z]Uniconazole was treated at 14 days after planting.
[y]No pinching, short-day, or uniconazole treatment.
[x]Pinching and short-day treated at 14 days after planting.
[w]The number of uniconazole treatments.
[v]Mean separation within columns by DMRT at 5% level.

once and 0.05 mg a.i./pot twice application, leaf chlorophyll content was increased by 0.95 μg · g^{-1}, 1.09 μg · g^{-1}, and 1.36 μg · g^{-1} (Table 2). Decrease in T/R ratio was inconsitsent with other reports that uniconazole increased T/R ratio (Wang and Gregg, 1989, 1990). This experiment showed that uniconazole did not influence leaf thickness (data not shown). Wang and Gregg (1989) found that chlorophyll content in leaves from uniconazole treated hibiscus was increased with increasing concentration following a drench application at 0.1, 0.2 or 0.4 mg/2.6-liter pot. In contrast, Steinberg et al. (1991) reported that uniconazole did not affect the chlorophyll content of 'Texanum' privet (*Ligustrum japonicum* Thunb.). Number of visible buds was slightly affected by the lower concentrations of uniconazole (Table 3).

Flower diameter was decreased by uniconazole treatment, but the stalk diameter was not affected by increasing concentrations of uniconazole. Flowering was delayed by 5 days or longer with treatment amount of 0.05 mg a.i./pot or higher. However, the number of flowers was greatly reduced at higher concentrations than 0.05 mg a.i./pot. Number of stomata was increased by uniconazole treatment (Fig. 1), which indicated that uniconazole-treated plants had a greater percentage of stomata cells per unit leaf area (Thetford et al., 1995). They reported that stomatal length was 20.1% shorter than the control; 16.1 μm vs. 20.2 μm for uniconazole-treated and non-teated plants, respectively. Stomatal width was similar betweeng treated and non-treated plants. A drench application of uniconazole increased stomatal density of 'Texanum' privet (*L. japonicum* Thunb.) (Steinberg et al., 1991), changed the balance of endogenous hormones, including gibberellins, abscisic acids, and cytokinins (Fletcher and Hofstra, 1985; Fletcher et al., 1986), and this was associated with higher cell density.

We examined histological changes of stem at 120 DAP to investigate the effect of uniconazole treatment on stem tissue development. The length of vascular tissues from uniconazole-treated plants (11.2 μm) was shorter than that of non-treated

Table 2. Effects of concentrations of uniconazole drenching[z] on the fresh weight, dry weight, chlorophyll content, and leaf deformity of *C. indicum* at 80 days after planting.

Treatment			Fresh weight (g)			Dry weight (g)			T/R ratio	Chlorophyll content (μg · g^{-1})	Leaf deformity (%)
Pinching	Short-day	Uniconazole conc. (mg a.i./pot)	Shoot	Root	Flower	Shoot	Root	Flower			
-[y]	-		97.90 a[v]	15.57 ab	18.49 a	17.11 a	2.34 a	2.69 a	8.07 ab	0.78 bc	-
+[x]	-		113.77 a	14.33 ab	18.60 a	17.99 a	2.46 a	2.73 a	8.31 a	0.81 b	-
+	+	0.00	91.47 a	19.73 a	18.51 a	13.64 b	2.24 a	2.71 a	7.09 ac	0.66 bc	-
+	+	0.05	68.17 b	16.03 ab	14.22 b	7.69 c	1.27 b	2.43 ab	7.06 ac	1.61 ab	8
+	+	0.10	56.97 b	12.47 ab	13.24 bc	6.56 c	1.06 b	2.32 ab	7.36 ac	1.75 a	15
+	+	0.15	53.93 b	12.87 ab	13.01 bc	6.03 c	1.13 b	2.31 ab	7.26 ac	2.02 a	32
+	+	0.05×1[w]	64.77 b	15.27 ab	12.85 bc	8.04 c	1.37 b	2.33 ab	6.62 bc	1.56 ab	9
+	+	0.05×2	61.37 b	15.03 ab	12.44 c	6.39 c	1.20 b	2.20 ab	6.41 c	1.81 a	16
+	+	0.05×3	62.07 b	9.77 b	12.53 c	6.44 c	1.02 b	1.91 b	7.40 ac	2.03 a	46

[z,y,x,w,v]Refer to Table 1.

Table 3. Effects of concentrations of uniconazole drenching[z] on the flowering of *C. indicum* at 120 days after planting.

Treatment			Days to visible bud fomtion	No. of visible buds (ea)	Flower diameter (cm)	Stalk length (cm)	Stalk diameter (cm)
Pinching	Short-day	Uniconazole conc. (mg a.i./pot)					
-[y]	-	-	103	49.00 de[v]	3.40 a	3.13 ab	0.12 a
+[x]	-	-	98	55.00 de	3.43 a	3.17 ab	0.12 a
+	+	-	64	105.00 ab	3.42 a	3.10 ab	0.14 a
+	+	0.05	69	131.67 a	2.70 c	2.50 c	0.14 a
+	+	0.10	72	73.33 cd	3.10 b	2.89 bc	0.15 a
+	+	0.15	72	100.00 bc	3.03 bc	3.21 ab	0.14 a
+	+	0.05×1[w]	70	124.33 ab	2.90 bc	3.37 a	0.12 a
+	+	0.05×2	73	72.33 cd	2.59 c	2.80 bc	0.13 a
+	+	0.05×3	81	74.01 cd	3.01 bc	3.21 ab	0.13 a

[z,y,x,w,v]Refer to Table 1.

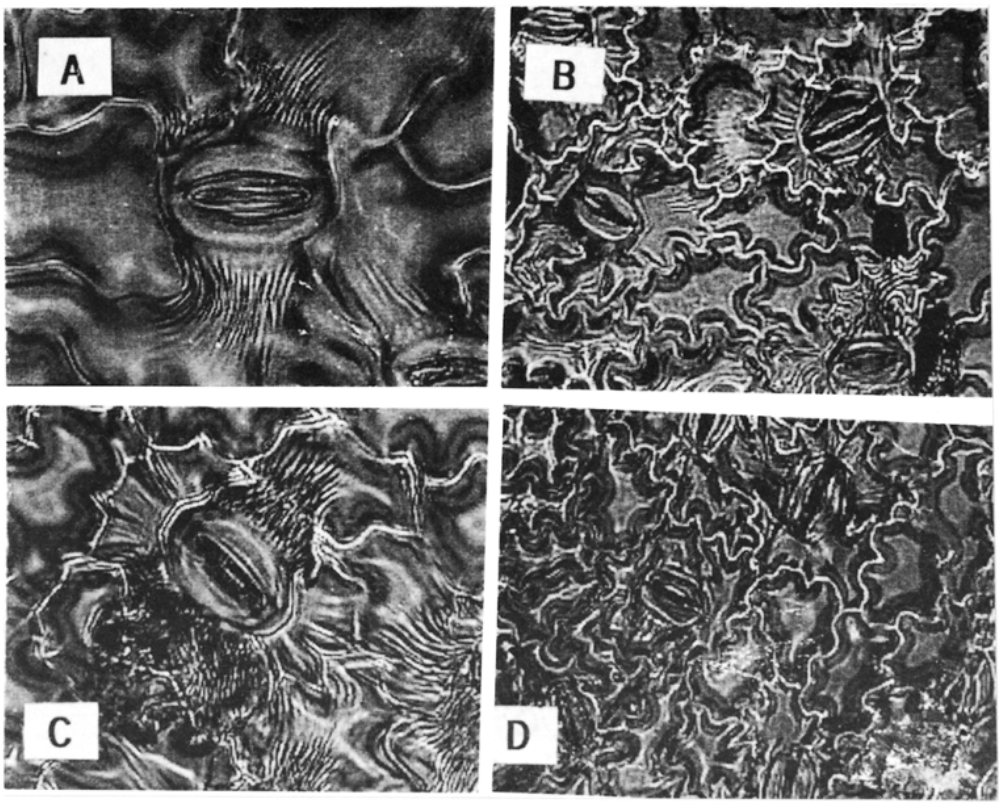

Fig. 1. Effects of uniconazole on the size and the number of stomata per unit leaf area of *C. indicum* at 120 days after planting. (A, B) Control, 400×, 200× (C, D) Uniconazole 0.05 mg a.i./pot, 400×, 200×

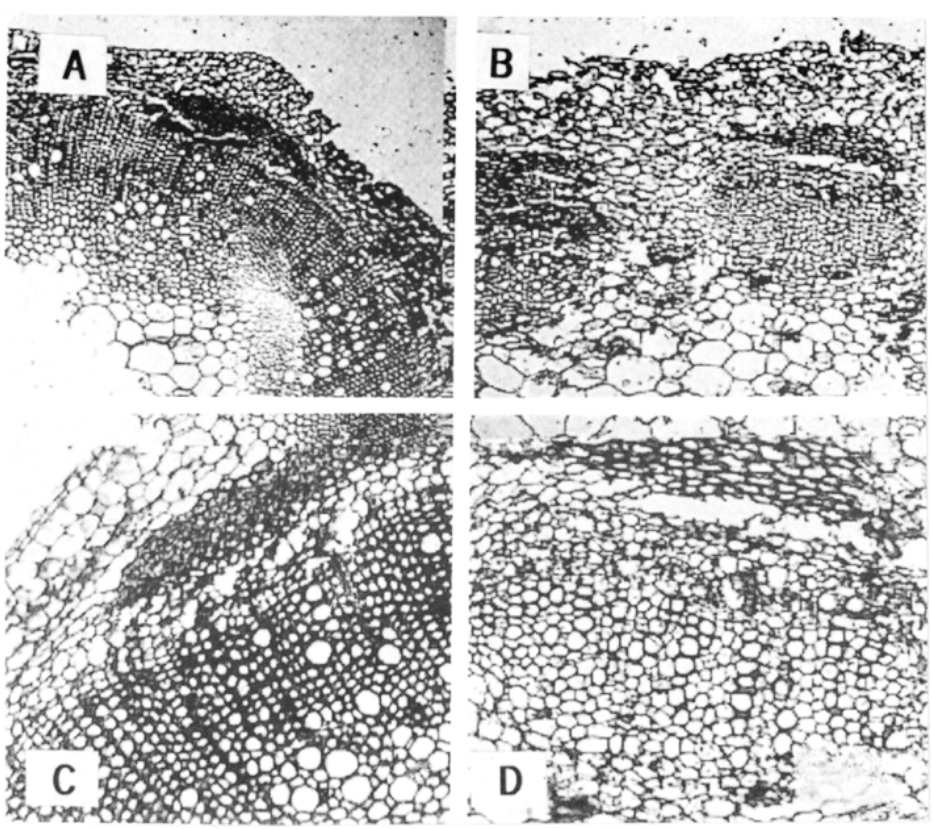

Fig. 2. Effects of uniconazole on the vascular bundles size and xylem diameter of *C. indicum* stems at 120 days after planting. (A, B) Control, 400×, 200×, (C, D) Uniconazole 0.05 mg a.i./pot, 400×, 200×

plants (15.0 μm), and the size of xylem vessel was also decreased by uniconazole treatment as shown in Fig. 2. This result was similar to the findings of Thetford et al. (1995) who reported that the initiation of secondary xylem for stem tissues of uniconazole-treated plants was suppressed and the length of xylem vessel of uniconazole treated plants was shorter than the control plants. Suppression of stem xylem tissues was reported to be similar for other plants treated with uniconazole. Internode diameter measurements of 2.6 and 2.2 mm were reported in non-treated and uniconazole-treated *Forsythia* x *intermdia* 'Spectabilis'. Individual xylem vessels of uniconazole treated plants, when viewed in cross sections, appeared to have smaller cross-sectional areas. Uniconazole-induced suppression of secondary xylem growth was reported in 'Jane Cowl' hibiscus (Wang and Gregg, 1989, 1990). When applied to roots, young stems, and the youngest leaves, triazole chemicals quickly moved into the plant and were translocated acropetally via the xylem to the leaves (Reed et al., 1989). These results are similar to the results with chrysanthemum [*Dendranthema* x *grandiflorum* (Ramat.) Kitamura], where uniconazole caused proper height control when applied 4 weeks after pinching, but resulted in excessive retardation when applied with pinching simultaneously or 2 weeks later (Gilbertz, 1992). A common problem with uniconazole application is overdosing, which could be lessened by applying the chemical later in the crop cycle when axillary branches are more fully developed (Gilbertz, 1992). From the facts described above, uniconazole treatment at 0.05 mg a.i./pot with pinching and SDT was recommened for high quality pot plant production of *C. indicum*.

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Uniconazole 농도가 분화용 감국의 생육 및 개화에 미치는 영향

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초 록

본 연구는 uniconazole 농도가 감국의 생육 및 개화에 미치는 영향을 구명하여 가장 효과적인 방법을 찾음으로써 양질의 분화용 감국 생산을 위한 기초자료를 얻고자 실시되었다. 삽목 발근묘를 정식 후 2주째 적심하고 uniconazole을 농도별로 토양관주하였으며, 같은 농도(0.05mg a.i./pot)를 1회, 2회, 3회로 나누어 관주하고 동시에 단일처리와 적심처리를 행하여 감국의 생육 및 개화반응을 살펴본 결과, uniconazole을 0.05, 0.10, 0.15mg a.i./pot로 증가시킴에 따라 초장은 41.6, 52.5, 58.5%로 감소되었다. 측지수는 0.05 mg a.i./pot 처리구에서 가장 많이 증가되었으며 초장(22.6cm)도 18cm 화분에 적합하였다. 그러나, 높은 농도(0.10, 0.15mg a.i./pot)는 초장(17.0, 14.8cm)이 지나치게 짧아서 적합하지 않았다. 단일처리와 적심처리를 수행하는 경우에는 가시적인 화아발생시까지의 기간을 단축시켰지만, uniconazole 처리에 의해서는 적심과 단일처리시의 효과를 5~9일까지 지연시켰다. 화아수는 0.05mg a.i./pot에서 가장 많은 경향을 보였으나 꽃직경은 uniconazole 처리시에 감소하는 경향을 보여 꽃이 작고 많은 형태가 되었다. 또한 0.05mg a.i./pot를 1회에 처리한 경우에 화아발생시까지의 기간이 비교적 짧았으며, 화아수도 증가하였다. 따라서 정식후 2주째 적심과 단일처리 후 uniconazole 0.05mg a.i./pot를 1회 토양관주함으로써 화분과 균형을 이루는 초장을 얻을 수 있으며, compact type의 분화를 생산할 수 있을 것으로 판단되었다.

추가 주요어 : 엽록소 함량, 식물생장조절제, 초장, 분화용식물