



## Controlled-release compound fertilizers improve the growth and flowering of potted *Freesia hybrida*



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### ABSTRACT

The controlled-release fertilizers (CRFs) are the fertilizers which gradually release their mineral nutrients, while at the same time providing proper nutrition to the plants. The CRFs have been widely used to improve crops' quality and quantity, but have not been applied on *Freesia hybrida* so far. In this study, *Freesia* 'Shangnong Ruxiang' was used to determine the effect of CRFs on its vegetative and reproductive growth. Two different kinds of commercial CRFs i.e. Osmocote Classic and Agroblen were applied in various doses. In an appropriate dose, Osmocote Classic and Agroblen improved the growth of *Freesia*. The overall effect of Agroblen is better than Osmocote. Under treatments of 5 g/L Osmocote and 5 g/L or 7 g/L Agroblen, the plant height, scape height, scape number, scape strength, and chlorophyll content were higher than other groups. Under 7 g/L Agroblen, the plants blossomed 10 days earlier than that of control. Taken together, 5 g/L of Osmocote and 5 g/L or 7 g/L of Agroblen are recommended for strong leaf and corm growth with good flowering phenotype, while 5 g/L or 7 g/L of Agroblen only is optimum for early flowering in *Freesia*.

### 1. Introduction

*Freesia hybrida*, a herbaceous perennial flowering plant in the Iridaceae family, is a popular floriculture crop with immense commercial importance. *Freesia* is mainly produced as a cut flower but also as a flowering potted plant (Anderson, 2006; Bezu, 2010). The feasibility of controlled-release types, rates and formulations, as well as plant nutrient use efficiency for *Freesia* under different CRF regimes are still rudimentary which may limit nursery productivity. The plants of *Freesia hybrida* mainly rely on corms to reproduce, so the main goal of the most *Freesia* growers is to produce more flowers or corms with maximum quality. One of the decisive factors influencing the growth and flowering of *Freesia hybrida* (cultivated in pots) is the proper fertilization. Although it has been reported that manure schedule of N, P and K plays a major role in successful production of *Freesia* (Thomas et al., 1998), while the general precise nutritional requirements of *Freesia* are not well understood still yet. With the increasing public concern about human health, environmental protection and sustainability of natural resources, it is conducive to develop environmentally friendly fertilizers. Over the past few decades, the emergence and development of controlled-release technology has been a solution to the global problem. By using controlled-release fertilizers (CRFs), the nutrients release to the soil at a controlled rate and provide adequate

nutrients for crop production with the optimum levels (And and Jibril, 2005; Du et al., 2006; Ni et al., 2010). Compared with the traditional fertilizers, the controlled-release fertilizers have less solubility in water and slow releasing of nutrients in the soil. Thus, reducing the loss of nutrients and increasing efficiency of nutrients with a single time of fertilizer application. The fertilizer efficiency is long-term, stable and continuously supplies nutrient for the entire growing period. Due to the slow release of fertilizer, a large amount of application will not lead to excessive soil salinity or "burn seedlings", thus the production costs are reduced at the same time (Arrobas et al., 2011; Shaviv, 2005; Zhao et al., 2010). In agriculture, CRFs have been mainly used in crops and vegetables, such as rice (Yang et al., 2014; Ye et al., 2013), cucumbers (Wang, 2007), tomato (Yan and Zhang, 2005), cabbage (Xiao-Hui et al., 2010), and also in few ornamental plants (Hou et al., 2008; Zhao et al., 2017). Recently, floricultural growers have become interested in using CRFs because of their beneficial effects to vegetative growth, flower production and underground storage organs. For example, the effects of CRFs with different longevities incorporated at different rates on the growth and quality (Andiru et al., 2013). It has been found that the CRFs improved the ornamental quality of *Chrysanthemum* by ameliorating the leaf chlorophyll content, photochemical transduction rate, and nutrient uptake (Song et al., 2011). Chen Y et al. analyzed the effect of CRFs on *Cuphea ignea*, *Hemerocallis lilioasphodelus*, Gaura, Lantana,

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*Cuphea hyssopifolia*, *Echinacea purpurea* and *Rudbeckia* (Chen et al., 2011). In *Argyranthemum frutescens*, the application of CRFs resulted in a vigorous plant growth (Schroeter-Zakrzewska and Kleiber, 2012). However, the response of *Freesia hybrida* to CRFs in pots has not been thoroughly examined.

The present study was carried out to find optimum doses of CRFs containing nitrogen, phosphorus and potash on growth and flowering parameters of *Freesia hybrida* grown in pots. This study will be useful to professionals, growers for both small as well as large (commercial level) production and suitable morphological values of *Freesia hybrida*.

## 2. Materials and methods

### 2.1. Plant material, growth conditions and experimental design

The experiments were conducted during November 2015 to June 2016 under the greenhouse conditions at Shanghai Jiao Tong University, Shanghai, China.

The healthy and uniform corms (diameter approx. 2–2.5 cm) were surface sterilized with 1:500 dilute carbendazim for 30 min. The corms were planted in plastic pots (2 L in volume with upper diameter in 16.5 cm and bottom diameter in 13.5 cm). The substrate was a mixture of common garden soil and compound substrate (Kangsheng Company, China) with 1:1 by volume. The CRFs used in this study were Osmocote Classic (total nitrogen, 14%; available phosphate, 14% and soluble potash, 14%, The Scotts Company) and Agroblen (total nitrogen, 9%; phosphorus pentoxide, 14%; potassium oxide, 19%; fetal magnesium oxide, 3% and 0.5% total iron, The Scotts Company). The CRFs were thoroughly mixed with the substrate before planting, with a concentration of 1, 3, 5, 7, 9, 11 g/L (Table 1). Six corms were planted in each pot and each experimental replicate consist of four pots. The same substrate was used for control with no additional fertilizers. Potted plants were placed in the greenhouse under natural photoperiod.

### 2.2. Growth parameters, plant sampling and analysis

After full expansion and elongation of leaves, plant height, leaf width, leaf thickness, and leaf number per plant were measured and recorded. The flowering process was recorded at 2–3 days' interval from scape appearing to petal fading. The date of early flowering period (1/5 plants flowered), full flowering period (3/5 plants flowered), fading period (3/5 plants started to withered), and the total blossoming days were recorded. The scape height, scape number per plant, scape strength (The stem strength apparatus, China), floret number of main scape and flower diameter (the first floret on the base of the main spike) were also measured after fully blossoming. After the flowering phase, samples were harvested for determination of fresh weight (FW) and dry weight (DW). Fresh weight (FW) was recorded immediately after harvesting. Dry weight (DW) was determined after drying samples for 48 h in a forced-draft oven at 60 °C. When the plants wilted, weight (perimeter over 1 cm), and number of total corms were measured and recorded.

After harvesting, the corm traits were measured, including the

**Table 1**  
Description of the treatments applied in experiment.

Treatment	Dosage of osmocote classic (g/L)	Treatment	Dosage of Agroblen (g/L)
CRFCK	0	CRFCK	0
CRFO1	1	CRFA1	1
CRFO2	3	CRFA2	3
CRFO3	5	CRFA3	5
CRFO4	7	CRFA4	7
CRFO5	9	CRFA5	9
CRFO6	11	CRFA6	11

average diameter of mature corms (perimeter in 7 cm and up), the fresh weight of mature corm, the number of mature corms and small corms (perimeter: 2–7 cm). Samples of fresh mature leaves were collected to measure the content of soluble protein, soluble sugar and chlorophyll by coomassie brilliant blue G - 250 dyeing method, anthrone colorimetric method and CCM-300 chlorophyll equipment (Aozuo Ecology Instrumentation Ltd., China), respectively (Hao et al., 2006).

### 2.3. Statistical analysis

The experiment was designed by the completely random method. Each treatment included four pots as four replicates. The significance of difference was analyzed by the Duncan's method. Results were statistically analyzed by using the One-Way analysis of variance (ANOVA) procedure at the significance level  $P \leq 0.05$  in SPSS 19.0 version software.

## 3. Results

### 3.1. The effect of CRFs on the biomass of *Freesia hybrida*

The controlled-release fertilizers Osmocote Classic and Agroblen both affected the biomass of *Freesia hybrida* significantly (Fig. 1). The FW and DW values of aboveground parts and corms fertilized with Agroblen were all higher than control. The highest FW (aboveground) and corms parts were observed in the group CRFA5, as 5.78 g and 5.56 g, respectively. Total weight of CRFA5 was the highest accordingly, which was increased 85.30% compared with the control group. The FW of CRFO5 and CRFO6 was 16.30% and 16.40% respectively, lower than control. In terms of DW, the highest value of aboveground parts and corms was observed in CRFA4 and CRFA5, respectively, 83.3% and 89.9% higher as compared with control. Similarly, the highest total DW was observed in CRFA5, increased by 86.3% compared with control. Among the groups, DW of the aboveground parts and the corms were both lowest in CRFO5, as 28.10% lower than control. Overall, in the corresponding concentration, the effect of Agroblen on the biomass was far better than Osmocote Classic. The excessive concentration of Osmocote Classic inhibited the biomass accumulation of leaves and corms of *Freesia*.

### 3.2. Effect of CRFs on vegetative growth of *Freesia hybrida*

A significant effect was observed on vegetative growth parameters such as plant height, leaf width, leaf thickness and leaf number. And the two CRFs had different effects on the vegetative growth under different concentrations (Table 2; Fig. 2). The plant height increased significantly with the application of CRFs. The highest plant height (34.7 cm) was observed in the group CRFA4, increased by 21.3% compared with CRFCK, followed by CRFO3 (33.77 cm). The plant height of CRFO5 and CRFO6 was lower than CRFCK, and the lowest value (25.73 cm) was recorded in CRFO6. In term of leaf thickness, the maximum value (0.38 cm) was observed in CRFO3, increased by 16.7% compared with CRFCK, followed by CRFA4. Thus, Osmocote Classic and Agroblen under appropriate concentrations promote the plant height for potted *Freesia*, while excessive concentration of Osmocote Classic has negative effects on plant growth.

### 3.3. Effect of CRFs on the flowering traits of *Freesia hybrida*

The results showed that Agroblen has a significant effect on flowering traits, while the effect of Osmocote Classic was quite limited (Table 3). The scape height of CRFA4 was 31.30 cm, (15.10% higher than the control group), followed by CRFA3 and CRFA2, 29.67 cm and 29.50 cm, respectively. The scape heights of CRFO4, CRFO5, CRFO6 and CRFA1 were lower than control, and the lowest was observed in CRFO6, 12.1%. In terms of floret number, it was higher under the

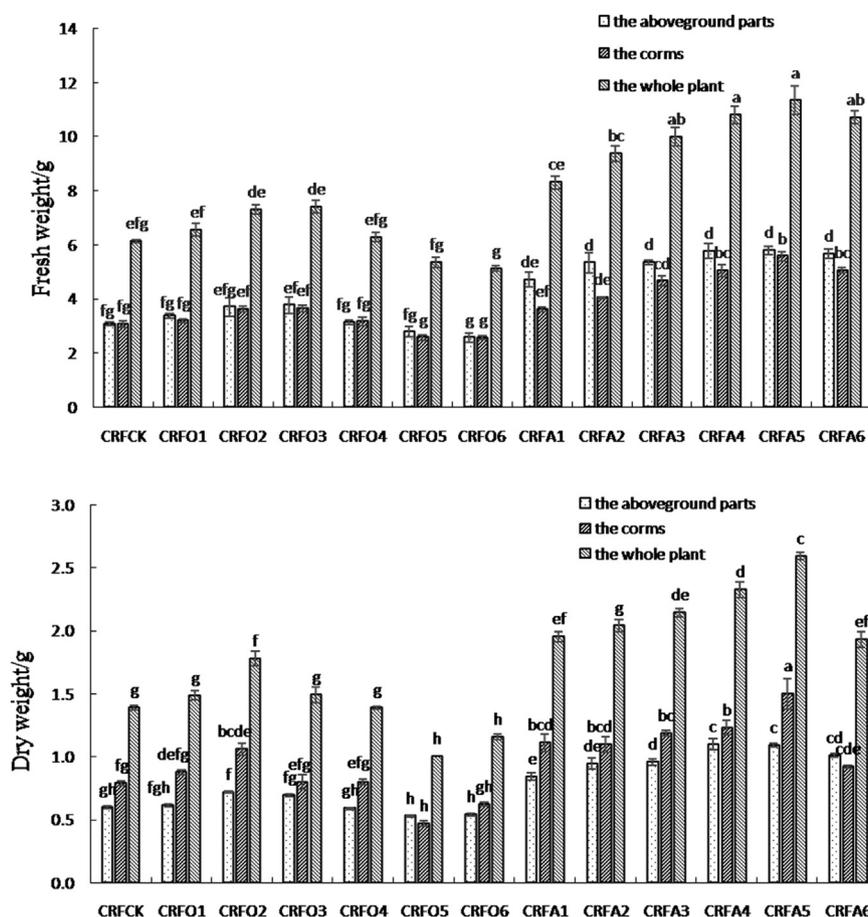


Fig. 1. The effects of CRFs on the biomass of *Freesia hybrida*. The lower case letter in the same column indicates the significant difference between treatments at  $P < 0.05$  based on the Duncan's new multiple range test.

treatments with Agrobien than that of Osmocote Classic with corresponding concentration. In CRFA3 and CRFA6, the floret number increased significantly as compared with control. However, no significant difference on scape diameter and strength was observed among the treatment groups. The scape number of each treatment group was higher than that of CRFCK and the largest number was observed in CRFA4. Furthermore, the scape number under treatments with Agrobien was larger than Osmocote Classic in the same dose. A similar trend was observed in the scape strength and the largest was noted in CRFA5 followed by CRFA4. The scape strength values under all treatment groups were also higher than control. The highest scape diameter was

observed in CRFO3, followed by CRFA3 and CRFA4. Thus, Agrobien containing potash fertilizer was conducive to promote the reproductive growth and improved the ornamental value of *Freesia hybrida*.

The CRFs also had an effect on flowering period (Table 4). The plants under the Agrobien treatments were all in advance in the flowering period, and the total blossoming days also increased in varying degrees. The squaring stage was 2 days earlier in CRFO3, while 4 days and 2 days later in CRFO5 and CRFO6 respectively as compared with control. CRFA2 and CRFA3 was squaring 8 and 7 days earlier than that of control group, respectively. At the flowering stage, CRFO3 flowered 4 days earlier and CRFA4 flowered 10 days earlier than control.

**Table 2**  
The effects of CRFs on the vegetative growth of *Freesia hybrida*.

Treatment	Plant height (cm)	Leaf width (cm)	Leaf thickness (cm)	Leaf number
CRFCK	28.60 ± 0.15 h <sup>a</sup>	1.03 ± 1.03a	0.33 ± 0.02bc	5.33 ± 0.42a
CRFO1	30.30 ± 0.38 g	1.00 ± 1.00ab	0.35 ± 0.02bc	5.67 ± 0.23a
CRFO2	31.73 ± 0.27ef	1.02 ± 1.02ab	0.32 ± 0.01c	5.57 ± 0.33a
CRFO3	33.77 ± 0.30b	1.04 ± 1.04a	0.38 ± 0.01a	6.00 ± 0.58a
CRFO4	30.90 ± 0.51fg	1.00 ± 1.00ab	0.36 ± 0.02abc	5.67 ± 0.31a
CRFO5	27.93 ± 0.18 h	1.02 ± 1.02ab	0.33 ± 0.02bc	5.67 ± 0.27a
CRFO6	25.73 ± 0.19i	1.02 ± 1.02ab	0.32 ± 0.01c	5.33 ± 0.36a
CRFA1	31.10 ± 0.29fg	0.93 ± 0.93b	0.35 ± 0.01bc	5.35 ± 0.23a
CRFA2	32.67 ± 0.41 cd	1.09 ± 1.09a	0.36 ± 0.01abc	5.67 ± 0.34a
CRFA3	32.27 ± 0.15de	1.07 ± 1.07a	0.34 ± 0.01bc	6.67 ± 0.53a
CRFA4	34.70 ± 0.15a	1.10 ± 1.10a	0.37 ± 0.02ab	5.67 ± 0.25a
CRFA5	33.13 ± 0.12bc	1.10 ± 1.05a	0.36 ± 0.01ab	6.65 ± 0.58a
CRFA6	32.23 ± 0.27de	1.09 ± 1.03a	0.34 ± 0.01bc	6.00 ± 0.55a

<sup>a</sup> Note: Values followed by the same lower case letter in each column are not significantly different at  $P < 0.05$  based on Duncan's new multiple range test. The same for the following tables.

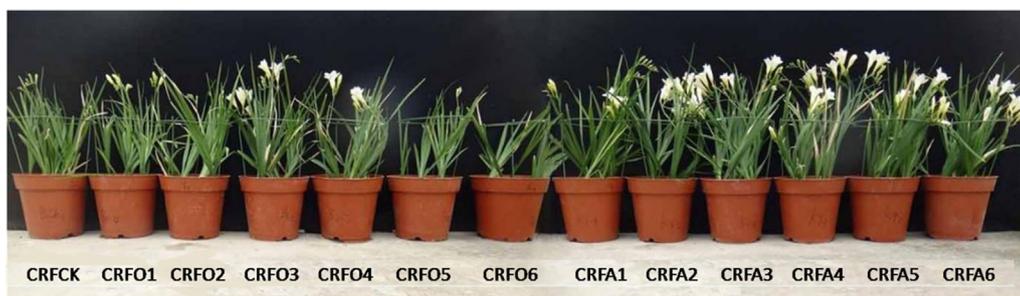


Fig. 2. The *Freesia hybrida* plants under the treatments of Osmocote classic and Agroblen.

Similarly, CRFO3 was 6 days earlier and CRFA1 was 5 days earlier than control. CRFO3 and CRFA4 reached to the fading period first, i.e. 4 days in advance than control, while CRFO5 fading 3 days later than control. The total flowering days of *Freesia hybrida* treated with Agroblen was more than that treated with Osmocote Classic or control, and the longest flowering period (23 d) was observed in both CRFA1 and CRFA2, a week longer than the control group (Table 4; Fig. 2).

### 3.4. Effect of CRFs on the corm growth of *Freesia hybrida*

After harvesting, the corm traits were analyzed. Application with Osmocote Classic and Agroblen both promote the growth of corms to a certain extent (Table 5). With the increase concentration of these two CRFs, mature corm diameter increased first and then decreased. The increase was observed in most treatments and a more significant promoting effect was present in the treatments with Agroblen than Osmocote Classic. The largest mature corm was recorded in CRFA3, as 2.17 cm in diameter, 27.6% higher than the control group, followed by CRFA4 and CRFO3, 2.15 cm and 2.07 cm, respectively. The mature corms were much smaller in CRFO5 and CRFO6, even smaller than control, and CRFO6 was the lowest, only 1.61 cm in diameter. The CRFs also promote the weight of mature corms. The change trend of the total weight of mature corms was similar with that of mature corm diameters. In CRFA3, the total weight of mature corms was the highest, corresponding to 2-fold increase as compared with control. CRFO2, CRFA2, CRFA3 and CRFA6 had slightly more small corms than control, 22, 22, 23 and 22, respectively. It is obvious that Osmocote Classic and Agroblen are both conducive to the growth of corms in proper concentration, but high doses will lead to a negative effect. Agroblen was more conducive to the corm development in *Freesia* as compared with Osmocote Classic.

### 3.5. Effect of CRFs on physiological characteristics of *Freesia hybrida*

Soluble protein, soluble sugar and chlorophyll are important substances involved in a variety of physiological and biochemical processes

in plants. Hence, the effects of Osmocote Classic and Agroblen treatments on these three indicators were analyzed (Table 6). Osmocote Classic increased the content of soluble protein in the leaves of *Freesia hybrida*, of which the value in group CRFO5 was the highest, 2.87 mg/g, followed by CRFO6, 2.80 mg/g. However, a limited effect was observed in the treatments with Agroblen. The content of soluble protein was slightly lower than control, and the lowest was recorded in CRFA6, corresponding to 94.3% of control. A significant increase in the content of soluble sugar was observed in all treated groups as compared with control. In treatments with Osmocote Classic, a gradual increase was present in a dose-dependent manner while an increase first, followed by a slight decrease was observed under the treatments with Agroblen in high dose. The chlorophyll content of all treated groups was significantly higher than the control group, and there was no significant difference among the high-dose treatments (3 g/L and above). The chlorophyll content of CRFA4 was the highest, as 67.77, higher 28.70% than control, followed by CRFO3.

## 4. Discussion

Up to date, very limited information is available on the precise nutritional needs of *Freesia hybrida* and very little research work has been carried out on the effect of controlled-release compound fertilizers (CRFs) on growth and flowering parameters of *Freesia hybrida*. In the present study, we found that CRFs Osmocote Classic and Agroblen both have a positive role/effect in promoting vegetative and reproductive growth of *Freesia hybrida* within appropriate concentration range. Generally, the plant height, scape height, scape strength, scape number, mature corm diameter and chlorophyll content were significantly enhanced and reached the highest value at 3 g/L, 5 g/L or 7 g/L (Fig. 3). Walker and Hunt (2000), testing four types of CRFs with three different application rates in Jeffrey pine, also found that morphological parameters, especially shoot growth response, generally increased with application rate. However, stunting occurred when the fertilizer concentration is too concentrated. These findings are in agreement with a previous study (Thomas et al., 1998). Similar effects were obtained in

Table 3  
The effects of CRFs on the flower traits of *Freesia hybrida*.

Treatment	Scape height (cm)	Scape diameter(cm)	Scape strength(N)	Flower diameter(cm)	Scape number	Floret number on the main spike
CRFCK	27.23 ± 0.32f	0.56 ± 0.01abc	15.24 ± 0.36c	3.65 ± 0.15a	4.65 ± 0.23c	5.67 ± 0.23bc
CRFO1	27.67 ± 0.27ef	0.55 ± 0.01abc	16.16 ± 0.34b	3.73 ± 0.02a	4.67 ± 0.31c	5.55 ± 0.33c
CRFO2	27.97 ± 0.22de	0.57 ± 0.01abc	16.60 ± 0.20ab	3.75 ± 0.06a	5.67 ± 0.33ab	6.33 ± 0.43abc
CRFO3	28.33 ± 0.24ef	0.59 ± 0.01a	16.37 ± 0.22b	3.72 ± 0.04a	5.55 ± 0.58ab	5.67 ± 0.30bc
CRFO4	25.17 ± 0.26 g	0.55 ± 0.01abc	16.26 ± 0.38b	3.69 ± 0.04a	5.00 ± 0.55ab	6.13 ± 0.32abc
CRFO5	25.23 ± 0.17 g	0.56 ± 0.02abc	16.14 ± 0.18b	3.73 ± 0.05a	5.33 ± 0.33ab	6.00 ± 0.25abc
CRFO6	24.03 ± 0.55 h	0.54 ± 0.02abc	16.19 ± 0.25b	3.70 ± 0.02a	5.00 ± 0.57ab	5.67 ± 0.33bc
CRFA1	27.03 ± 0.19 f	0.52 ± 0.01c	16.25 ± 0.26b	3.68 ± 0.05a	5.00 ± 0.33ab	5.67 ± 0.33bc
CRFA2	29.50 ± 0.35bc	0.56 ± 0.02abc	16.10 ± 0.19b	3.70 ± 0.05a	5.55 ± 0.58ab	6.50 ± 0.31ab
CRFA3	29.67 ± 0.33b	0.58 ± 0.02ab	16.79 ± 0.26ab	3.73 ± 0.05a	5.53 ± 0.30ab	6.67 ± 0.29a
CRFA4	31.30 ± 0.57a	0.57 ± 0.02abc	17.12 ± 0.40a	3.69 ± 0.03a	6.01 ± 0.43a	6.50 ± 0.38ab
CRFA5	29.13 ± 0.28bcd	0.53 ± 0.02bc	17.27 ± 0.25a	3.70 ± 0.04a	5.77 ± 0.33ab	6.55 ± 0.33ab
CRFA6	28.53 ± 0.32cde	0.55 ± 0.02abc	16.28 ± 0.26b	3.67 ± 0.06a	5.00 ± 0.55ab	6.67 ± 0.32a

**Table 4**  
The effects of CRFs on the flowering periods of *Freesia hybrid*.

Treatment	Date of squaring period	Date of early flowering period	Date of full flowering period	Date of fading period	Total flowering days (d)
CRFCK	10th March	28th March	4th April	12th April	16
CRFO1	11th March	27th March	4th April	10th April	15
CRFO2	10th March	26th March	3rd April	11th April	17
CRFO3	8th March	24th March	29th March	8th April	16
CRFO4	11th March	27th March	4th April	13th April	18
CRFO5	14th March	30th March	6th April	15th April	17
CRFO6	12th March	29th March	4th April	11th April	14
CRFA1	4th March	21st March	30th March	12th April	23
CRFA2	2nd March	20th March	31st March	11th April	23
CRFA3	3rd March	21st March	1st April	11th April	22
CRFA4	4th March	18th March	1st April	8th April	22
CRFA5	5th March	21st March	3rd April	9th April	20
CRFA6	6th March	22nd March	2nd April	11th April	21

**Table 5**  
The effects of CRFs on corms development of *Freesia hybrida*.

Treatment	Mature corm diameter(cm)	Fresh weight of mature corms (g)	No. of mature corms	No. of small corms
CRFCK	1.70 ± 0.03fgh	3.04	7	21
CRFO1	1.75 ± 0.03efg	3.62	7	17
CRFO2	1.84 ± 0.04de	4.00	8	22
CRFO3	2.07 ± 0.03b	5.64	10	19
CRFO4	1.79 ± 0.02def	3.76	7	20
CRFO5	1.68 ± 0.03gh	3.11	5	18
CRFO6	1.61 ± 0.03h	5.18	6	14
CRFA1	1.84 ± 0.03de	4.72	5	19
CRFA2	2.07 ± 0.02b	5.54	6	22
CRFA3	2.17 ± 0.04a	6.16	9	23
CRFA4	2.15 ± 0.04ab	4.81	7	20
CRFA5	1.95 ± 0.04c	4.60	7	21
CRFA6	1.88 ± 0.03cd	5.13	7	22

**Table 6**  
The effects of CRFs on some physiological characteristics of *Freesia hybrida*.

Treatment	Soluble protein (mg/g)	Soluble sugar (%)	Chlorophyll (SPAD unit)
CRFCK	2.64 ± 0.01e	13.70 ± 0.58e	52.67 ± 1.07c
CRFO1	2.65 ± 0.02e	14.25 ± 0.06de	57.80 ± 1.55b
CRFO2	2.74 ± 0.01d	14.64 ± 0.15de	63.93 ± 2.64a
CRFO3	2.75 ± 0.01 cd	15.15 ± 0.40 cd	63.67 ± 2.03a
CRFO4	2.78 ± 0.01bc	15.20 ± 0.57 cd	65.90 ± 1.57a
CRFO5	2.87 ± 0.01a	15.87 ± 0.10bc	65.13 ± 0.98a
CRFO6	2.80 ± 0.01b	16.80 ± 0.12ab	65.20 ± 0.81a
CRFA1	2.57 ± 0.01 g	15.68 ± 0.30c	58.77 ± 0.99b
CRFA2	2.60 ± 0.01fg	16.97 ± 0.03a	65.73 ± 2.11a
CRFA3	2.62 ± 0.01ef	16.19 ± 0.34abc	66.63 ± 0.76a
CRFA4	2.58 ± 0.01 g	16.03 ± 0.32abc	67.77 ± 0.67a
CRFA5	2.59 ± 0.02fg	15.71 ± 0.17c	65.97 ± 1.58a
CRFA6	2.49 ± 0.01 h	15.95 ± 0.27bc	64.13 ± 0.76a

*Coreopsis grandiflora*, the plants grown with the doses of 2.5 and 3.5 g dm<sup>-3</sup> of substrate were higher than the plants with the other doses (Kozik et al., 2004). In a pot experiment of *Calla palustris*, plant height, growth potential and chlorophyll content in CRF treatments were better than control (Hou et al., 2008). While in another experiment conducted on *Pinus halepensis* seedlings under CRF, shoot/root ratio was significantly affected (increased with the highest value 3.3 g/g) using CRF. Mineral nutrition and growth of containerized *Pinus halepensis* seedlings under CRF.

Comparing the application effect of the Osmocote Classic and Agroblen, we found that plants treated with Agroblen had a higher biomass in general, both FW and DW significantly higher than that of Osmocote Classic. In addition, the application of Agroblen made *Freesia hybrida* plants flowering earlier and also flowering period longer. We

can speculate that this will move up the time of *Freesia hybrida* coming into the market and increase the length of ornamental period, which will bring huge economic benefits to the growers. Overall, application with Osmocote Classic and Agroblen both can advance the flowering time, but a more significant effect was found under the treatments with Agroblen. The difference between two CRFs is perhaps due to that Agroblen contains more potassium but less magnesium and iron. It's well known that potassium fertilizer can promote the synthesis and transportation of carbohydrates, which make the plant vigorous. For instance, in peaches, application of K fertilizer (as a treatment) favorably induced peach flowers to bloom 2-days earlier, and specifically contributed to flower development at full bloom stage (Song et al., 2011). This has also been confirmed in other similar studies. Preparation and properties of chitosan-coated NPK compound fertilizer with controlled-release and water retention. In *Chrysanthemum*, the application of potassium fertilizer led to flowering ahead of time, increased plant height, number of leaves, and larger flowers (Zeb, 2015), which is consistent with our findings. Likewise, magnesium and iron are elements necessary for the synthesis of chlorophyll, and may also play a catalytic role (Shaahan et al., 1999). Moreover, the chlorophyll content in the Agroblen treatment group was correspondingly increased in *Freesia*. Osmocote Classic was helpful to increase soluble protein content, while Agroblen was more conducive for chlorophyll synthesis.

Among all treatments, CRFO3, CRFA3 and CRFA4 (groups) showed a higher value in plant height, scape diameter and scape strength, suggesting increased ornamental value and the enhanced lodging resistance in *Freesia*. In addition, flower diameter and floret number was increased to different extent in CRFO1. Thus, the two CRFs promote vegetative growth at the same time and did not bring adverse effects to the reproductive growth. Under the treatments of CRFO2, CRFO3, CRFA2 and CRFA3, more corms were harvested, and mature corms were bigger than control and other treatments. To sum up, we recommend CRFO3 (Osmocote Classic 5 g/L), CRFA3 (Agroblen 5 g/L) and CRFA4 (Agroblen 7 g/L) as reasonable fertilizer concentrations. If entering the market ahead of time is considered, CRFA3 (Agroblen 5 g/L) and CRFA4 (Agroblen 7 g/L) are the optimum selections in potted *Freesia hybrida*, which would guide the future practice.

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#### Conflicts of interest

The authors declare that there is no conflict of interest to claim.

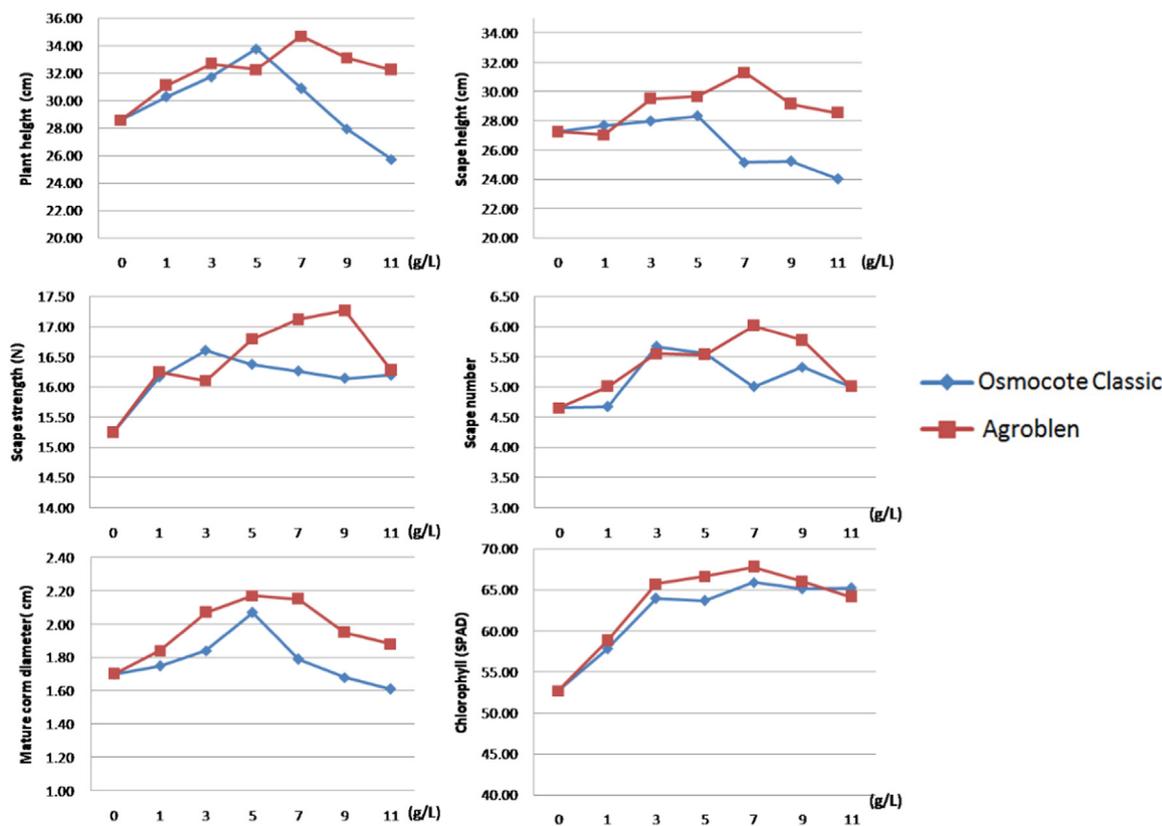


Fig. 3. The change trend of plant height, scape height, scape strength, scape number, mature corm diameter and chlorophyll content under CRFs treatments in potted *Freesia hybrida*.

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