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Diversity of morphological characteristics and propagation by bulb chipping in rain lily (*Zephyranthes* sp.) in Vietnam

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Abstract

Vietnam is one of the countries with high biodiversity, with extremely rich and diverse genetic resources of flowers and ornamental plants, which are precious and valuable in the domestic and international markets. Currently, in Vietnam, rain lilies have many different shapes and colors. This study focused on evaluating the growth characteristics of ten different varieties of rain lily and the ability to propagate these varieties by bulb chipping method in winter-spring in Hanoi, Vietnam. The results show that there was a great diversity in growth characteristics among lily varieties in terms of the number of leaves (4.4 to 12.7), leaf length (8.3-22 cm), leaf width (2.4-9.7 mm), leaf thickness (1.0 to 1.7 mm), leaf angle (23-50^o), and tillering ability in six months (0 to 5.8 branches/bulb). The flower colors were also diverse, such as white, light pink, dark pink, orange, and white. The number of petals was 6 or 12 petals, along with the diversity of flower structure. The ten varieties showed a different propagation capacity by bulb chipping ranging from 1 to 17 multiplication times. The bulbils derived from bulb chipping had good quality, with the highest number of bulbils in the treatment of the four-piece chipping. Therefore, the method can be applied to rain lily propagation in Vietnam.

Key words: Morphological characteristics, propagation, bulb chipping, rain lily, *Zephyranthes*, Vietnam

Introduction

Rain lily (*Zephyranthes* sp.) is a tropical plant in the genus *Zephyranthes*, belonging to the family Amaryllidaceae. In addition to the name rain lily, other common names can be recognized as fairy lily, rain flower, zephyr lily, and magic lily (Austin, 2004). This family is one of the most widely known ones for ornamental values (Katoch and Singh, 2015; Reyes-Chilpa *et al.,* 2011; Jin, 2013). Rain lily is an herbaceous, bulbous, and perennial plant with about 10-30 cm height. This plant is also characterized by elegant, delicate and beautiful leaves and various flower colors. Rain lilies are very diverse in types, shapes and colors. So they are used as flower beds in family home or school campus. It is estimated that about 60-90 species are in the genus *Zephyranthes* (Felix *et al.*, 2011; Hutchinson, 2003; Tapia-Campos *et al.*, 2012). In addition to ornamental purposes, rain lily has also been used as medicine, treating common ailments such as headaches, colds and coughs to complex diseases such as breast cancer, diabetes, rheumatism, bulbculosis (Ho, 2000; Jin, 2013; Katoch and Sigh, 2015; Reyes-Chilpa *et al.*, 2011; Vangalapati *et al.*, 2013).

The genus *Zephyranthes* can be found in the western hemisphere and higher altitude areas like Mexico, Argentina and Brazil (Hutchinson, 2003; Meerow *et al.*, 1999). This genus is also been cultivated and used for ornamental and medicinal purposes in places with temperate to tropical weather conditions like India, Hawaii, Indonesia, Thailand and Vietnam (Ho, 2000; Katoch and Singh, 2015; Meerow *et al.*, 1999).

In Vietnam, rain lilies are used to treat hair loss, cough, and fever (Ha *et al.*, 2019; Ho, 2000). Rain lily (*Zephyranthes*) with Vietnamese names called Toc Tien or Hue Mua. The name Hue Mua is rooted in the country's flower blooming time, which is usually in late summer until the end of autumn, after heavy rains (Ha *et al.*, 2019). Rain lilies have increasingly won customers' hearts with the advantages of diverse colours, shapes and high vitality. In Vietnam, popular flower varieties are sold for 20,000-30,000 VND per 1 pack of 10 seeds. Meanwhile, prices of bulbs range from 10,000-500,000 VND/1 bulb and can be higher depending on the variety. In the worldwide market, the *Zephyranthes* 'Candida' Amaryllis, indigenous to the United States, is priced at $8.99 per bulb, while the *Zephyranthes* "Prairie Sunset," a native Amaryllis of the Americas, commands a price of $11.99 per bulb (Ebay, 2022). The rain lily is acknowledged for its significant economic contribution to the floriculture industry and the broader agricultural sector.

Initially, there were only two indigenous varieties of rain lily in Vietnam: yellow and pink ones (Ho, 2000). Due to customers' needs, some varieties of rain lily have been imported from abroad. So, rain lily flowers now have rich colors from white, yellow, and orange to pink, and purple. However, the market for rain lilies in Vietnam remains underdeveloped. The popular variety grown and traded is only pink rain lilies (*Zephyranthes rosea*) (Ha, 2019). Although white and yellow rain lily varieties are grown in Da Lat, Da Nang provinces, the market share for these types is very modest. Another challenge comes from the collection, propagation and breeding of rain lily varieties in Vietnam, which is still weak and cannot meet consumer needs.

To the best of our knowledge, there has been a lack of studies

on the collection, evaluation and storage of genetic resources to maintain development for the selection and creation of new varieties in Vietnam. Notably, research on rain lily propagation seems absent in the existing literature. Reasonable propagation methods will provide a large number of bulbils for both research and production of rain lilies. In other words, collecting, conserving, propagating and commercializing the rain lily in Vietnam is very urgent. The present study aimed to collect some popular varieties of rain lily grown in North Vietnam (Hanoi city and Lang Son province) and imported varieties sold in Vietnamese shops and evaluate the possibility of propagating by chipping bulbs.

Materials and methods

Plant materials: Plant materials include five different varieties of rain lily collected in the North of Vietnam (Hanoi city and Lang Son province) and the other five imported varieties imported from Europe in separate 7x10 cm plastic cups. Monitoring indicators included time of root appearance after cuttings, percentage of shoot forming pieces (%), average number of roots/piece, quality of shoots (number of leaves/buds, length and width of leaves), diameter of bulbs and bulb circumference after 120 days (four months).

Results and discussion

Diversity of morphological and growth characteristics in ten rain lily varieties: The main morphological characteristics of 10 rain lily varieties in terms of leaf length, leaf width, leaf thickness, and leaf angles, number of leaves, bulb diameter and number of new branches are shown in Table 1. Accordingly, the leaf length of rain lily varieties varied quite widely, ranging from 10.9 to 27.2 cm, with the largest leaf length of VN1 and the smallest of VN4. The differences in leaf length among varieties are also mentioned in the review of Katoch and Singh (2015). It seems more apparent that imported varieties had small differences in leaf length than domestic ones, which has not been clearly mentioned in previous work. While two imported varieties, namely IM2 and IM3, had the highest width of leaves (1.06 and 1.16 cm respectively), the lowest belonged to domestic varieties of VN3 and VN5 (0.3 cm). In terms of leaf thickness, the values ranged from 0.1 to 0.2 across ten varieties. It can be seen that leaf angles significantly varied among varieties, but there was more fluctuation in a domestic group compared to the imported one. Specifically, the highest angle of leaves was 80.80 in VN1, which was over two times higher than the lowest of 36.20 in VN3. Meanwhile, the differences in leaf angles of imported varieties ranged from 41.6 to 60.90. In the study, bulb diameter varied from 1.31 cm (in VN4) to 2.62 cm (in IM2), which seems to be lower than the values of 2.5-5 cm in the findings of Tapia-Campos *et al.* (2012). However, this result is supported by Dash *et al.* (2020), which revealed that the bulb diameter of three different *Zephyranthes* species ranged from 1 to 2.5 cm. Various reasons may explain this difference. For instance, the different varieties of rain lily used in the two studies may lead to differences in bulb

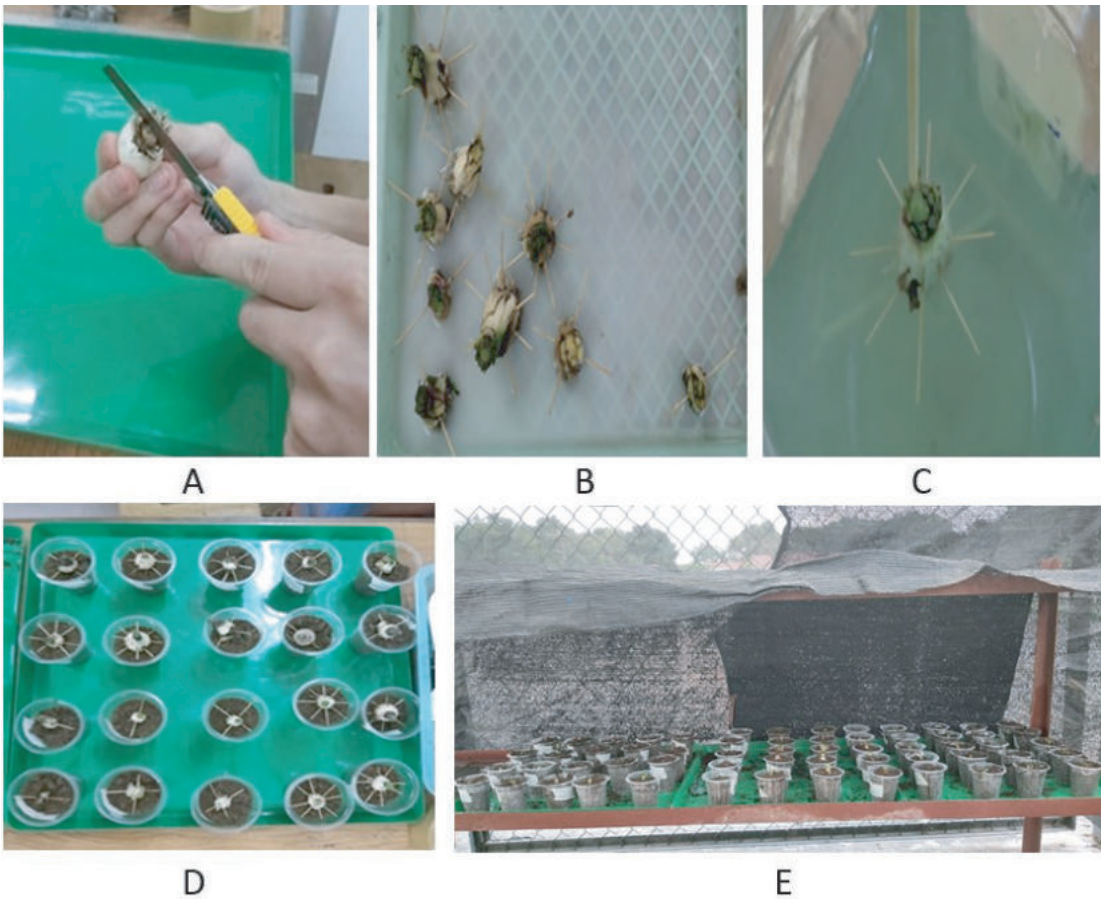

Fig. 1. Experimental procedure for chipping bulbs. (A) Use a sharp knife to cut the bulbs into pieces that do not separate from the bulbs. (B) Disinfect the bulbs with Daconil antifungal solution. (C) Soak the bulbs in N3M rooting stimulator. (D) Plant the bulbs in the media in separate plastic cups. (E) Take care the chipped bulbs for 120 days under shade nets.

diameters. Another reason is differences in geographical locations with climate conditions, which can influence the growth of rain lily and its bulb size as mentioned in Tapia-Campos *et al.* (2012). This study contributed to existing knowledge on the morphology of rain lilies by comparing morphological characteristics among different varieties, especially between imported and native rain lilies.

Another characteristic of rain lily varieties observed in this study is the number of leaves, which also had apparent differences among such varieties. In this study, the number of leaves was 7.6 on average, which is similar to the estimation of Prasad *et al.* (2017). Three varieties with the highest leaves of over 10 appeared in VN5, VN3 and IM3, while the remaining ones had average leaves from 4.4 to 8.0. In addition, bulb diameters fluctuated from the lowest of 1.31 cm (in VN4) to the highest of 2.62 cm (in IM2). Finally, a very clear difference in the number of new branches between domestic and imported variety groups occurred, which is little known from previous scholars. Accordingly, the domestic varieties had much higher new branches (1.4 to 5.2) than imported counterparts (0 to 1.4) in six months. Within the domestic group, there were also disparities in the numbers of new branches among different varieties, with the highest of 5.8 in VN3 and the lowest of 3.2 in VN4.

The distinctions in morphological characteristics among the 10 varieties are clearly evident, particularly when comparing domestic and imported groups, as illustrated in Fig. 2. Overall, there were difference in morphological characteristics among various rain lily varieties. The leaf width of imported group was higher than that in the domestic counterpart. The difference in leaf sizes found in this study aligns with a previous work (Katoch and Singh, 2015). The number of leaves and leaf angles had higher disparities in domestic group against the imported one. Domestic varieties had the lowest and highest relative values (measured in % compared to the maximum of 100%) in numbers of leaves and leaf angles, while narrower distances in values of such characteristics appeared among imported varieties. More importantly, it is evident that domestic varieties had much higher numbers of new branches than imported ones. The imported varieties have meager tillering ability (no tillering or single branching during the 6 months of study). Therefore, finding out the propagation method for these varieties is important in developing varieties in Vietnam.

Leaves are a very important part of the plant, playing a major role in the synthesis and accumulation of nutrients during the growth and development of the plant. Therefore, during the growth and development of the plant, the speed of making new leaves will greatly affect the ability to increase the size of flower bulbs. To see clearer changes and growth of leaf numbers among 10 varieties across ten given periods (one-week intervals), we reported the numbers of leaves over ten times, from December 4th 2021 to Feb. 6th 2022 (Table 2). The final column indicated the number of new leaves calculated from the difference of the 10th and 1st measured leaf lengths. By the tenth time, VN5 had the highest number of leaves, with an average number of 12.7, followed by VN3 and IM3, with 11.6 and 10.6, respectively. Also, VN5 had the most rapid increase in new leaves (8.4 leaves in average), followed by VN3 with seven leaves and IM3 with 6. Meanwhile, the smallest changes in new leaves appeared in VN4 and IM5, with an average of 2.4 new leaves. In terms of relative changes (growth rate of leaf numbers), VN5 also experienced the highest increase rate in the numbers of leaves, over three times between the first and tenth periods. Through a meticulous examination of leaf numbers in imported and native rain lilies, our study enhances the existing body of knowledge on the morphological characteristics of *Zephyranthes* species, providing valuable insights to build upon previous research.

The increase in leaf length of rain lily varieties over ten period of time (from Dec. 4 to next year Feb. 6) is reported in Table 3. Overall, all ten rain lily varieties had a quite increase in their leaf length during observed periods of time, especially in the first four weeks. Specifically, around 2-3 times higher leaf length between the first and forth times in all varieties was observed and there were moderately steady increases in the remaining weeks. This change pattern occurred with all ten varieties of rain lily.

At the first time, the leaf length of VN5 was the highest at 10.7 cm, followed by IM3 and IM1. Meanwhile, VN1 variety ranked fourth among ten varieties in the first week. However, by period, VN1 variety recorded the longest leaf with an average of 27.1

Table 1. Morphological characteristics of the ten rain lily varieties collected in Vietnam in the study

Variety	Origin	Leaf color	Leaf length (cm)	Leaf width (cm)	Leaf thickness (cm)	Leaf angle (°)	Number of leaves	Bulb diameter (cm)	Number of new branches*
VN1	Lang Son, Vietnam	Dark green	27.2	0.65	0.10	42.9	7.0	2.57	5.2
VN2	Lang Son, Vietnam	Light green	18.5	0.56	0.10	80.8	5.3	1.52	3.6
VN3	Lang Son, Vietnam	Light green	20.7	0.30	0.18	36.2	11.6	1.55	5.8
VN4	Hanoi, Vietnam	Light green	10.9	0.38	0.10	77.1	4.4	1.31	3.2
VN5	Hanoi, Vietnam	Dark green	26.6	0.30	0.20	37.9	12.7	1.52	3.6
IM1	Imported variety	Dark green	24.1	0.40	0.20	45.0	5.4	2.32	1.4
IM2	Imported variety	Dark green	23.0	1.06	0.12	41.6	5.4	2.62	0.6
IM3	Imported variety	Light green	26.7	1.16	0.10	55.1	10.4	2.34	0.8
IM4	Imported variety	Dark green	20.4	0.48	0.20	47.5	8	1.66	0.4
IM5	Imported variety	Light green	17.1	0.46	0.10	60.9	5.4	1.72	0

* Number of new branches formed at six months after planting

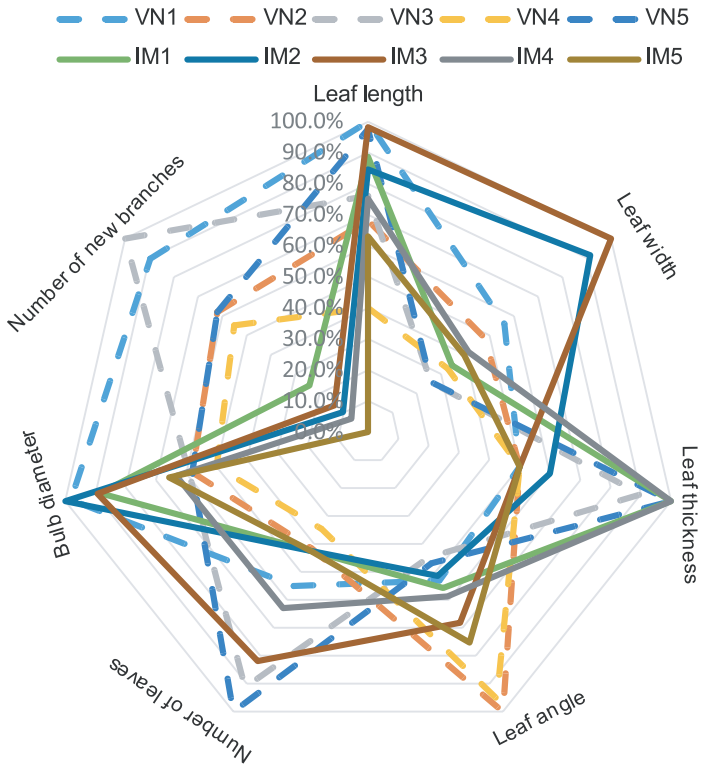

Fig. 2. The difference in morphological characteristics of the ten rain lily varieties in percentage compared to the maximum value of each morphological value

cm, followed by VN5 and IM3 varieties with leaf lengths of 26.5 and 26.6 cm, respectively. Notably, the growth rate of leaf length increase reached the highest value in VN2 variety, with a level of over 4 times higher in the first compared to the tenth times (equivalent from 4.0 cm to 18.7 cm). Meanwhile, variety VN4, starting from a leaf length of 4.2 cm, had a quite low growth rate and lowest leaf length of 10.8 cm among ten rain lily varieties at 10th period.

Different flower varieties have completely different flower, fruit, and seed characteristics such as flower colour, scape length, diameter, durability, morphology, etc., which are also the characteristics that flower customers are most interested in. The varieties were found to have very different flower morphological characteristics (Table 4 and Fig. 3). Color, number of stamens, and number of petals are the characteristics of the breeders and can be easily distinguished. The variety with the long scape usually has a large diameter. For example, the IM4 variety with the most significant bulb length of 27.1 cm has a large flower diameter of 6.8 cm. About flower durability, most varieties have flower durability in about 1-2 days. Flower durability depends greatly on weather conditions. Flowers often fade quickly in hot weather or heavy rain; in light sunny weather, the flowers stay fresh and reach maximum durability. Most of the varieties have six petals. The only 12-petal variety is IM5, which has stamens attached to the petals, so the anthers are often located on the petals or sometimes disappear altogether, causing the flower to lack stamens and petals.

Table 2. The increase in the number of leaves of the ten rain lily varieties over the observations

Variety	Number of leaves										Number of new leaves*
	1st time (4 Dec.)	2nd time (11 Dec.)	3rd time (18 Dec.)	4th time (25 Dec.)	5th time (1 Jan.)	6th time (8 Jan.)	7th time (15 Jan.)	8th time (22 Jan.)	9th time (29 Jan.)	10th time (6 Feb.)	
VN1	3.4	3.4	3.8	4.3	5	5.4	5.9	6.3	6.6	7.4	4.0
VN2	2.0	2.2	2.6	3.2	3.6	4.2	4.5	4.7	5.0	5.3	3.3
VN3	4.6	5.2	5.5	6.5	8.5	9.7	10.6	10.5	11.2	11.6	7.0
VN4	2.0	2.0	2.1	2.3	2.6	3.2	3.5	3.8	4.0	4.4	2.4
VN5	4.3	5.5	6.2	7.5	9.8	11	11.7	12.2	12.5	12.7	8.4
IM1	2.4	2.8	3.2	3.4	3.8	4.2	4.4	5.2	5.4	5.4	3.0
IM2	2.4	2.4	2.8	2.8	3.4	4.0	4.8	5.2	5.4	5.4	3.0
IM3	4.6	5.0	5.2	5.4	7.4	9.2	10	10.4	10.6	10.6	6.0
IM4	3.6	4.0	4.4	4.4	5.4	6.0	7.0	7.4	8.0	8.0	4.2
IM5	3.0	3.0	3.6	3.6	4.0	4.4	5.0	5.2	5.4	5.4	2.4

*The value is determined by the difference of the 10th and 1st measured leaf lengths

Table 3. Growth of leaf length of the ten rain lily varieties

Variety	Leaf length (cm)									
	1st time (4 Dec.)	2nd time (11 Dec.)	3rd time (18 Dec.)	4th time (25 Dec.)	5th time (1 Jan.)	6th time (8 Jan.)	7th time (15 Jan.)	8th time (22 Jan.)	9th time (29 Jan.)	10th time (6 Feb.)
VN1	7.6±0.89	11.6±1.01	16.5±0.89	19.5±1.01	21.1±0.9	21.6±1.11	22±1.01	22.5±1.01	24±0.89	27.1±0.91
VN2	4.0±2.21	6.3±0.89	11.7±2.21	15.2±0.91	16.3±1.30	16.6±0.89	17.0±2.21	17.5±1.01	18.1±0.91	18.7±1.01
VN3	6.2±0.89	8.5±1.01	13.4±0.30	17±0.90	18.0±0.89	18.5±0.40	19.0±0.89	19.4±0.89	20±1.01	20.6±1.30
VN4	4.2±0.50	6.0±0.89	7.0±0.89	7.7±2.1	8.6±1.01	9.0±0.89	9.4±2.21	9.8±0.89	10.3±1.34	10.8±1.11
VN5	10.7±1.30	14.4±1.01	18.9±0.91	22.9± 2.1	24±1.01	24.5±0.91	24.9±1.05	25.3±0.89	25.9±1.0	26.5±0.89
IM1	8.4±0.91	11.9±0.89	16.0±2.10	20.8±1.01	22.1±0.9	22.6±1.01	23.0±0.89	23.4±1.01	24±0.89	24.6±0.91
IM2	7.3±0.89	10.1± 2.10	15.3±0.89	19.5±1.11	21±0.89	21.4±1.05	21.9±2.21	22.3±1.05	22.9±1.01	23.4±1.01
IM3	10.1±0.9	14.9±1.01	19.9±1.02	22.5±1.01	24.1±1.3	24.7± 2.1	25.2±0.9	25.6±0.10	26.2±2.21	26.6±1.05
IM4	7.5±0.89	11.7±2.21	13.7±0.9	17.2±0.91	18.1±0.8	18.5±1.01	19.0±0.8	19.4±0.91	19.8±0.9	20.4±2.21
IM5	6.4±1.01	8.4±0.89	10.4±0.91	13.7±0.9	14.6±1.1	15.1±2.1	15.5±1.01	15.9±1.01	16.4±0.89	16.9±1.11

Table 4. Flower characteristics of the ten rain lily varieties in the study

Variety	Flower scape length (cm)	Flower diameter (cm)	Petal color	Number of petals per flower	Number of anthers	Number of pistils per flower	Pistil position relative to stamens	Durability of one flower (days)
VN1	16.1	4.6	Light pink	6	6	1	Higher	1.6
VN2	25.2	5.1	Dark pink	6	6	1	Higher	1
VN3	24.3	5.6	White	6	6	1	Higher	1.5
VN4	23.9	4.9	Dark pink	6	6	1	Lower	2
VN5	17.2	4.3	White	6	6	1	Higher	2
IM1	26.5	6.2	Red	6	6	1	Higher	1.5
IM2	24.3	5.7	White pink	6	6	1	Higher	1.5
IM3	16.7	6.2	White pink	6	6	1	Lower	1.5
IM4	27.1	6.8	White striped pink	6	6	1	Higher	2
IM5	18.8	5.4	Light pink	12	3	1	Higher	2

Propagation ability of rain lily varieties by bulb chipping: In the experiment to evaluate the propagation ability by chipping bulbs, each variety of all 10 varieties was tested for propagating ability by chipping the bulbs into 2, 4 and 8 parts. In the domestic varieties of Vietnam, each method of chipping bulbs includes three plants and imported varieties, due to the limited number of bulbils, we use one bulb for each treatment. Bulbs were selected of equal size in each treatment. Most of the chipped bulbs were alive at 100%, except for the chipped bulbs into eight pieces in the IM3 variety. Table 5 shows the morphological characteristics of the bulbils formed from the chipped bulbs. Most of the bulbs that are chipped produce a large number of bulbils. The morphological characteristics of the bulbils showed healthy vigour (Fig. 4). The number of leaves of the bulbil ranges from 2 to 4, the diameter of the bulbs is about 3 to 13 mm, the number of roots is from 4 to 10 roots, the length of the roots reaches 5-12cm. The formula for chipping bulbs into 4 gave the highest number of bulbils formed after 120 days. In the statistical analysis of the difference between the morphological characteristics, we found that, for the most part, there was not a big difference between the treatments for bulb chipping. Therefore, chipping the bulbs into four is considered suitable for chipping the bulbs of rain lily for a high number of bulbils and good quality. In particular, among imported varieties, we can see that the propagation efficiency is quite high, ranging from 6.5 to 17.7.

When planted in normal conditions without chipping bulbs, these varieties have a very low tillering rate, from 0 to 1 branch. Therefore, the chipping of bulbs is very meaningful in the propagation of imported rain-lily varieties in Vietnam. Previous studies examined propagation efficiency through the *in vitro* method in one variety of *Zephyranthes* (Gangopadhyay *et al.*, 2010; Mujib *et al.*, 2013). Afroz *et al.* (2018) analyzed the reproductive biology of the genus *Zephyranthes*. Our study is one of the first to describe the quality of bulbils produced by bulb chipping in various *Zephyranthes* varieties. In the Amaryllidaceae family, several experiments on propagation by bulb chipping in Hippeastrum species were carried out (Khalid Jamil *et al.*, 2014; Phuong and Hang, 2014; van Leeuwen *et al.*, 1997). These studies reported an average of 1.25 bulbils per piece and cut one *Hippeastrum* bulb into 32 pieces. In our study, for *Zephyranthes* species, which are smaller in bulb size than Hippeastrum species, it is appropriate to chip bulbs with smaller pieces (from 2 to 8).

This study is one of the first reports about the diversity of morphological, tillering characteristics and propagation by chipping off some indigenous and imported varieties in Vietnam. Imported varieties show a diversity of flower colours that complement the native gene pool, usually white and dark pink. Indigenous varieties with high tillering rates are suitable for large landscape decoration and for producing raw materials for medicinal purposes. The imported varieties have low tillering capacity, but diverse flower colours are suitable for decoration in smaller landscapes and should be propagated by chipping bulbs. In the future, it is necessary to research and breed more varieties of rain lily to serve the needs of landscape and medicinal plants in Vietnam.

Fig. 3. Flower images of the ten rain lily varieties

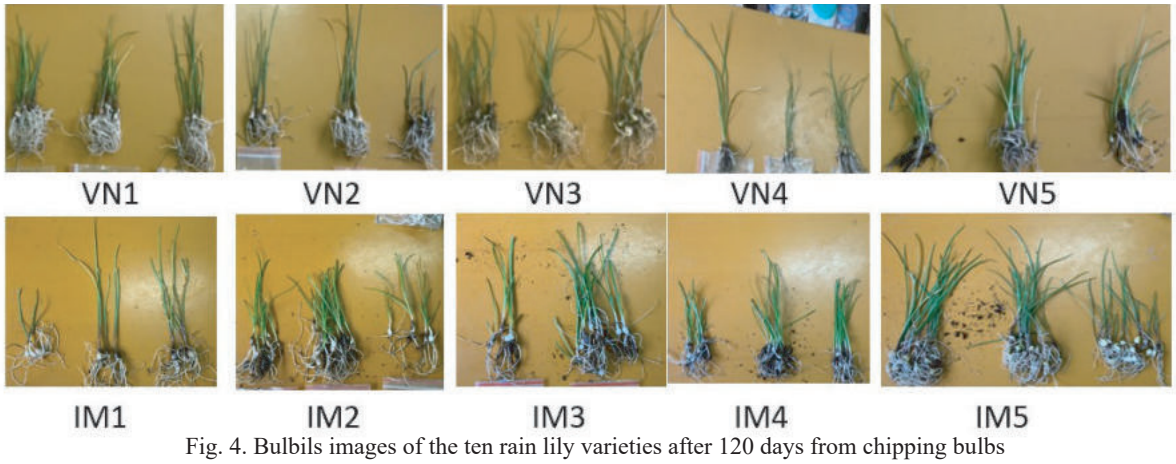

Fig. 4. Bulbils images of the ten rain lily varieties after 120 days from chipping bulbs

Table 5. The morphologies of bulbils formed from the methods of chipping bulb after 120 days

Variety	No. of split pieces	Number of formed bulbils	Plant height (cm)	No. of leaves	Bulb diameter (mm)	No. of roots	Length of the longest root (cm)
Morphology of the bulbils from stem splitting (each treatment contains three bulbs)							
VN1	2 (n=3)*	22	12.4^{a}	3.6^{a}	4.3^{a}	10.1^{a}	11.3^{a}
	4 (n=3)	24	10.7^{a}	2.7^{b}	7.0^{b}	6.9^{b}	9.9^{a}
	8 (n=3)	20	13.1^{a}	3.0^{ab}	7.9^{b}	8.3^{b}	11.3^{a}
VN2	2 (n=3)	6	11.0^{a}	2.8^{a}	5.3^{a}	5.5^{a}	8.4^{a}
	4 (n=3)	14	9.5^{a}	2.6^{a}	4.7^{a}	8.1^{a}	7.7^{a}
	8 (n=3)	8	10.4^{a}	2.4^{a}	4.6^{a}	6.9^{a}	8.6^{a}
VN3	2 (n=3)	9	19.2^{a}	7.1^{a}	13.9^{a}	16.9^{a}	12.4^{a}
	4 (n=3)	14	18.5^{a}	3.6^{b}	9.9^{b}	9.1^{b}	12.9^{a}
	8 (n=3)	10	16.6^{a}	2.0^{b}	7.6^{b}	6.4^{b}	4.9^{b}
VN4	2 (n=3)	12	17.0^{a}	3.2^{a}	3.3^{a}	7.6^{a}	5.9^{a}
	4 (n=3)	10	15.0^{b}	2.6^{a}	3.2^{a}	5.1^{a}	7.4^{a}
	8 (n=3)	5	10.1^{b}	2.6^{a}	4.8^{a}	6.0^{a}	8.0^{a}
VN5	2 (n=3)	13	7.9^{a}	8.8^{a}	4.3^{a}	9.4^{a}	6.0^{a}
	4 (n=3)	3	8.8^{a}	8.7^{a}	2.7^{a}	5.7^{a}	5.3^{a}
	8 (n=3)	2	8.3^{a}	4.5^{a}	4.0^{a}	7.0^{a}	5.5^{a}
Morphology of the bulbils from stem splitting (each treatment contains one bulb)							
IM1	2 (n=1)	3	16.5^{a}	2.3^{a}	5.0^{a}	10.0^{a}	9.7^{a}
	4 (n=1)	3	16.9^{a}	2.7^{a}	6.0^{a}	9.7^{a}	13.8^{a}
	8 (n=1)	3	8.0^{b}	2.0^{a}	5.3^{a}	5.3^{a}	8.2^{a}
IM2	2 (n=1)	7	7.5^{a}	2.4^{a}	2.3^{a}	4.0^{a}	5.2^{b}
	4 (n=1)	17	6.5^{a}	2.4^{a}	2.7^{a}	3.9^{a}	5.9^{ab}
	8 (n=1)	4	7.2^{a}	3.3^{a}	3.5^{a}	3.8^{a}	9.2^{a}
IM3	2 (n=1)	3	8.5^{a}	3.0^{a}	3.7^{a}	6.3^{a}	8.1^{a}
	4 (n=1)	10	8.2^{a}	2.9^{a}	3.9^{a}	5.5^{a}	8.9^{a}
	8 (n=1)	died					
IM4	2 (n=1)	8	9.8^{ab}	3.0^{a}	3.4^{a}	5.9^{a}	7.2^{a}
	4 (n=1)	11	10.8^{a}	2.5^{a}	3.3^{a}	5.8^{a}	5.8^{a}
	8 (n=1)	7	7.8^{b}	2.9^{a}	3.1^{a}	3.9^{a}	5.9^{a}
IM5	2 (n=1)	10	17.7^{a}	2.8^{a}	5.7^{a}	8.2^{a}	10.2^{a}
	4 (n=1)	15	15.4^{a}	2.7^{a}	3.5^{b}	5.1^{b}	9.6^{a}
	8 (n=1)	14	10.1^{b}	2.0^{b}	5.1^{a}	5.0^{b}	9.1^{a}

*n means number of tubers used in the treatment

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