Journal of Interdisciplinary Science Topics

The Feasibility of Genetically Engineering a Smeraldo Flower

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17/02/2023

Abstract
In the Bangtan Sonyeondan musical and cinematic universes, the fictional smeraldo flower have been referenced in images and lyrics. Working from visual clues presented in images associated with the band, this article aims to provide base species and mechanisms from other flowers that could be integrated together to create the smeraldo flower.

Keywords: *Music; Biology; Genetic Engineering; BTS; Smeraldo Flower*

In their music and universe, BTS references the mythological smeraldo flower. For their album *Love Yourself: Tear*, the photograph in figure 1 was posted on twitter [1], and the photograph in figure 2 on their smeraldo blog [2], with the flower making appearing in their *Love Yourself: Highlight reel* [3]. The flowers used as props are likely white flowers that have been cut and grown in blue dye to produce the colouring, and this article will explore how flowers may be crossed and engineered to produce the smeraldo flower.

Figure 1 – Photograph of the smeraldo flowers posted before the Love Yourself: Tear album was released and showing their colouration and shape [1].

Defining features
The flower has blue, pink, and white colouring, with all the colours in each petal rather than each petal being defined by one colour. The leaf shape is a toothed oval shape. The head of the flower has layers of petals, with varying sizes and lengths of petals in a layered appearance. These features are best exemplified in figures 1 and 2.

Figure 2 – Comparison of the smeraldo flower and *Lilium "*Muscadet" structure. Left: Photograph of the smeraldo flower from the official BTS blog [2]. Right: Photograph of *Lilium* "Muscadet" flowers[3] to highlight their flower and petal structure.

Base flower
In order to produce the prop for the music videos, a white flower appears to have been grown in pink and blue dyes to create the colouring. From figure 1, compared to the human face, the petals are significantly large which eliminates flowers with smaller petals from forming the base flower, like *Myosotis alpestris.* In figure 2, the smeraldo flower from the blog is presented beside a *Lilium* "Muscadet" [4].

Additional petals

Compared to *Lilium* "Muscadet", the smeraldo flower similar shaped petals, with the smeraldo flower having near double those of *L.* "Muscadet". To create the additional whorl, natural double-flowered oriental lilies occur due to mutations in the AG orthologue, or due to abnormal interactions with trans-regulatory elements [5]. Delaying the termination of the floral meristem termination through auxin production can lead to the production of additional whorls and double-flowering, although this is typically difficult to achieve in *Lilium* [5]. Auxin producing genes were upregulated in double-flowered lilies [5], suggesting that, in order to produce the smeraldo flower, gene expression would need to be induced. The stem and leaves also show similarities with those from a hybrid tea rose, like *Rosa hybrida*, shown in figure 3 below, and so the double flowering lily would be crossed with *Rosa hybrida* plant for their oval leaf with toothed edges. While there is some variation in size in the source materials, figure 2 highlights some of the main similarities between *Lilium* "Muscadet" and the smeraldo flower, and how double flowering in the lily could create the base flower for the smeraldo flower.

Figure 3 – Photograph showing the stem and leaf of *Rosa hybrida* [6]. Compared to figure 2, the similarities of the stem and leaf physical features between *R. hybrida* and the smeraldo flower can be seen.

Colouring

Blue colouring in flowers is less naturally occurring in comparison to other colours. *Hydrangea macrophylla* can naturally produce blue flowers and the colour is similar to the blue in the smeraldo flower. The colour of the sepals of *H. macrophylla* are regulated by the pH of the soil that it grows in; acidic conditions shift the colouration towards blue sepals, and alkaline conditions tend towards red sepals as the Al^{3+} uptake is affected by changes in pH [7]. In *H. macrophylla*, the blue colouration is due to a metal complex named "hydrangea-blue complex", composed of three co-pigments and Al^{3+} ions in aqueous solution at pH 4.0 [8]. In the *Rosa* genus, the colouration of petals is dependent upon anthocyanins, carotenoids, and flavonol [9, 10]. The *Rosa* sp. with pink petals accumulated a low level of anthocyanins, a higher level of flavonol, and little to no levels of carotenoids [10].

The smeraldo flower, shown in the figures above, contains pale blue and pink pigmentation across the petals. *Lilium* "Muscadet", shown in figure 2, can naturally occur coloured with the pale pink pigmentation, and thus this would not need to be manipulated. In *H. macrophylla,* delphinidin-3-glucoside is the main colour determining pigment, with the natural colour being red and, when in a higher aluminium concentration, it turns blue [11]. The delphinidin can be produced from anthocyanins, which are produced using the genes: *F3H, F3'H, and F3'5'H* [12]. In order to introduce blue colour to the smeraldo flower, these genes from *H. macrophylla* could be selected for using cross breeding, or could be introduced using gene editing technologies. However, as higher aluminium concentrations can be toxic to plants [12], the stabilising mechanism of *H. macrophylla* would also have to be integrated into the genome of the lilies in order to produce a stable smeraldo flower.

Conclusion

To produce a physical smeraldo flower through selection and crossbreeding alone would be an intensive, time consuming, and expensive process. To create a similar flower, a pale pink double flowered oriental lily would be the base to form the correct flower and petal structure. The stem and leaf would come from the *Rosa canina*, and the colouring would require anthocyanins. In order to produce a stable blue colouring in the petals, the delphinidin producing genes from *H. macrophylla* would be inserted, as would the genes associated with tolerating the higher aluminium concentrations. Producing the smeraldo flower this way would be intensive in comparison to growing a base flower in coloured dyes, but a new species of flower, *Lilium smeraldo*, could be engineered.

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