BREEDING AS A TOOL FOR IMPROVING POSTHARVEST QUALITY CHARACTERS OF LILY AND TULIP FLOWERS

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Abstract

Segregation of postharvest quality characters was studied in lily and tulip. A large variation in longevity of both lily and tulip flowers was found within populations tested at individual plant level. Other postharvest quality characters like number of flowers per stem, male sterility (lily) and stem elongation (tulip) also varied within the populations tested. Due to the high correlations between the offspring and their corresponding parental genotypes for several characters, breeding for a considerable improvement of postharvest quality in future cultivars seems promising.

1. Introduction

The quality of ornamentals is important because it is a key factor in the competition on the rapidly growing international flower market. Commercially, lily and tulip are the most important bulb crops for cut flower production in The Netherlands. The ornamental value of cut flowers is determined by a large number of quality characters. Documentation of the main quality characters of lily and tulip cultivars and knowledge about the segregation of these characters in cross breeding should be of value to the breeder, when using existing cultivars for breeding.

Existing lily and tulip cultivars differ markedly in their flower quality characteristics (Benschop and De Hertogh, 1969; 1970; Van der Meulen-Muisers and Van Oeveren, 1993). The purpose of this study was to determine the segregation of several flower quality characters in lily and tulip populations after harvest, and, to investigate the perspectives for improving these characters by cross breeding.

2. Materials and Methods

Bulbs of 45 lily populations and 32 tulip populations were produced at CPRO-DLO. Populations originated from crosses with 10 parental Asiatic hybrid lily cultivars or 12 parental tulip cultivars and seedling clones.

The flowers were forced, harvested and evaluated for their quality characters utilizing standardized conditions outlined by Van der Meulen-Muisers *et al.* (1992) and Van der Meulen-Muisers and Van Oeveren (1993). Plants were forced in a growth chamber at 17°C, 60% relative humidity (RH), 24 W/m² (lily) or 15 W/m² (tulip) using high pressure metal halide lamps (HPI-T 400W, Philips) during 16-h per day. Lily

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inflorescences were harvested at anthesis of the most mature floral bud. Tulips were harvested at unfolding of the petals. Cut flowers were placed in tap water without additives in a climate room at 17°C (lily) or 14°C (tulip), 60% RH, 3 W/m² using fluorescent lamps (TL-D84 36W, Philips) during 12-h per day.

Lily bulbs were weighed before planting, the number of floral buds was counted at harvest and male sterility was scored as present or absent. In lily individual flower longevity was defined as the time between bud anthesis and wilting. Number of buds per 25 g of bulb weight (representing the average bulb weight necessary to obtain flowers), and the mean individual flower longevity calculated per stem were used for analyses. Tulip stem length was measured both at harvest and at the end of flower life. Tulip flower longevity was scored as the time between unfolding of the petals and petal abscission.

Evaluation of quality characters was carried out at individual plant level within populations and at clonal level for the parental genotypes. Per population 21 (lily) or 36 (tulip) descendants were tested. Per clone 9 (lily) or 18 (tulip) plants were tested. Correlation coefficients (r) were calculated between parents and offspring to determine the breeding value of the parents and also between different quality characters to evaluate possibilities of indirect selection.

3. Results

Individual flower longevity of the parental genotypes ranged from about 4 to 8 days in lily and from about 8 to 16 days in tulip. Longevity values of the descendants evaluated at individual plant level ranged from about 2 to 11 days in lily and from about 6 to 22 days in tulip (Fig.1). Correlation coefficients (r) calculated between the mean flower longevity of the offspring and their corresponding parental genotypes was 0.87 and 0.54 in lily and tulip, respectively. In general the average longevity of populations was intermediate to or conformed with the longevity levels of their parents, although in tulip deviations occurred in 20% of the populations tested. For the remaining 80% of the populations and their corresponding parents a correlation coefficient of 0.81 was determined.

Within lily populations, the number of buds per inflorescence calculated per 25 g of bulb weight gave a broad segregation ranging from about 1 to 19 buds. Among parental cultivars, the number of buds which developed per 25 g of bulb weight ranged from about 4 to 9 buds (Fig.2). The correlation coefficient (r) between the mean number of buds of the offspring and the corresponding parental genotypes was 0.54. This correlation improved to 0.63 when bulb weights exceeding 50 g were excluded from the calculation.

Postharvest stem elongation in tulip was mainly due to elongation of the upper internode (data not shown). Among the parental genotypes stem elongation ranged from about 3 to 13 mm per day and in the offspring from 0 to 28 mm per day (Fig.3). The correlation coefficient between mean flower longevity of the offspring and their corresponding parental genotypes was 0.73. This was mainly determined by the male parent (male only: r=0.85; female only: r=0.24).

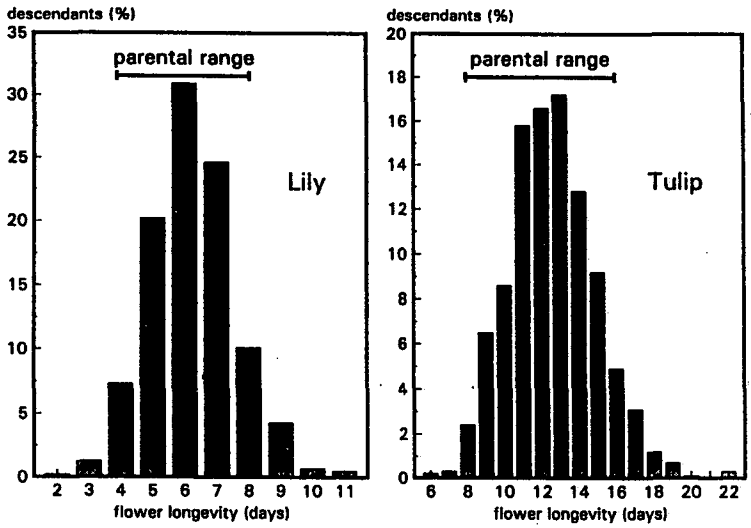

Fig. 1: Segregation of longevity values within the descendants of 45 lily populations (N=853 descendants) 32 tulip populations (N=978 descendants) evaluated at individual plant level and the range of longevity values within their corresponding parental genotypes.

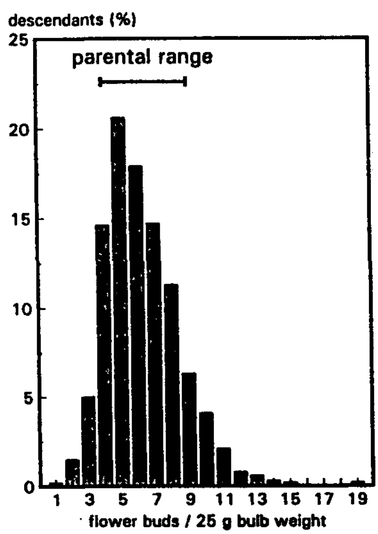

Fig. 2: Segregation of number of buds per 25 g of bulb weight within the descendants of 45 lily populations (N=859 descendants) evaluated at individual plant level, and the range of number of buds within their corresponding parental genotypes.

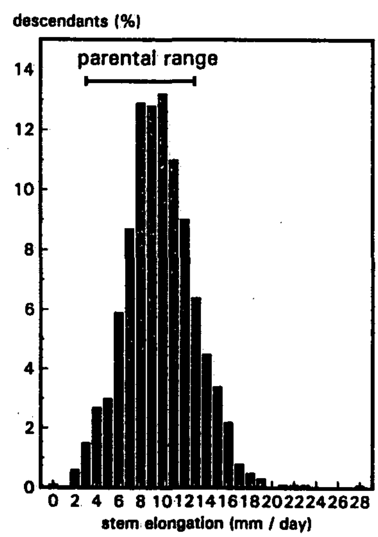

Fig. 3: Segregation of postharvest stem elongation in mm per day within the descendants of 32 tulip populations (N=978 descendants) evaluated at individual plant level, and the range of postharvest stem elongation within their corresponding parental genotypes.

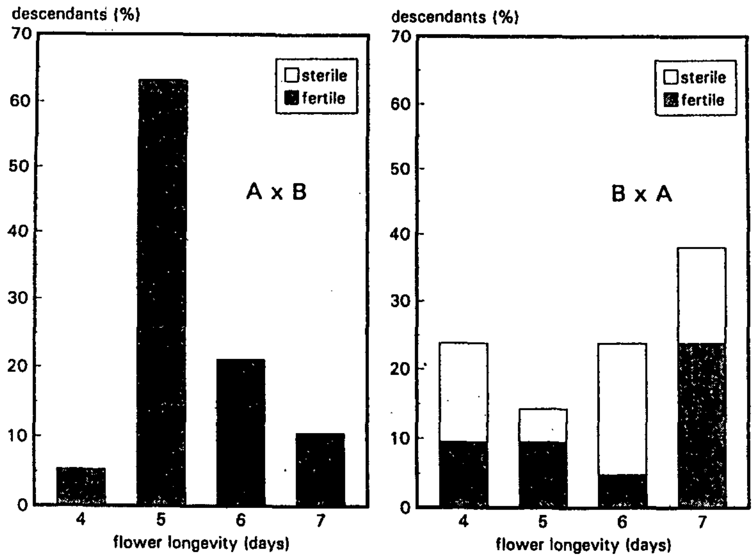

Fig. 4: Segregation of individual flower longevity and male sterility within a reciprocal pair of crossings of Asiatic hybrid lilies; N=19 (left) or N=21 (right) descendants.

Male sterility occurred in 73% of the lily populations tested corresponding with 23 % of all descendants tested. Relatively many male sterile plants occurred in offspring from three cultivars used as the female parent, whereas the breeding value for male sterility of these same cultivars was considerably less when used as the male parent (Fig.4). In 64% of the populations containing male sterile descendants, male sterile plants showed a higher average individual flower longevity than male fertile plants, although a large segregation in flower longevity existed independently of the formation of pollen (Fig.4).

No important correlations between flower longevity and number of buds per 25 g of bulb weight within lily, and flower longevity and postharvest stem elongation within tulip were detected.

4. Discussion

Flower longevity is a difficult genetic character to assess because it is influenced by conditions prevalent preharvest, at harvest and postharvest (Halevy and Mayak, 1979). However, by using standardized conditions to reduce non-genetic variation in longevity of cut lily and tulip flowers (Van der Meulen-Muisers *et al.* 1992; Van der Meulen-Muisers and Van Oeveren 1993), flower longevity of parents and offspring correlated rather well. This indicates that in order to obtain an acceptable flower longevity in future cultivars, it would be advisable to use longer lasting cultivars for breeding.

Although variation in number of buds per stem within lily genotypes is generally known to depend on bulb weight, the correlation between parents and offspring in number of floral buds per unit of bulb weight was not very high. This correlation might be influenced by differences in bulb weight and growth vigour among genotypes, since it has been reported that the contribution of each additional unit of bulb weight to an additional increase in the number of buds per stem decreases especially if extremely heavy bulbs are used (Van der Meulen-Muisers and Van Oeveren, 1996). When genotypes with bulb weights over 50 g were excluded from the calculation, the correlation coefficient between the number of buds per unit bulb weight of parents and offspring, considerably increased. Therefore, to increase the number of flower buds in new cultivars, parental genotypes with a higher number of buds per unit of bulb weight should be chosen for cross breeding. However, if selection takes place at individual plant level genotypes represented by extremely heavy bulbs might be underestimated for their bud number.

To reduce stem bending in cut tulip flowers stem elongation during vase life should be minimal. From the results reported here it can be concluded that postharvest stem elongation is a genetic character that parental tulip cultivars pass on to their descendants. Cross breeding with selected parental cultivars which have a minimal increase in stem length after harvest can lead to new cultivars with reduced postharvest stem elongation. Within the specific genotypes tested the contribution of male parents to stem elongation of their offspring, appears to be greater than that of the female parent.

Although lily anthers are a definite ornamental feature of the flower, the consumer often dislikes the pollen because of the way it permanently stains clothing. Male sterile plants would solve this problem. Three parental lily cultivars were found to be a probable source of cytoplasmic male sterility.

In earlier experiments concerning two lily populations tested at clonal level, the data suggested that male-sterile flowers tend to have longer vase life than male-fertile flowers of the same population (Van der Meulen-Muisers *et al.*, 1996). Therefore, the breeding value of the three cultivars mentioned above, used as a female parent, will be judged better for improved flower longevity than might be supposed from their phenotype in case of a positive correlation between male sterility and flower longevity. Although this positive correlation occurred in 64% of the populations tested in the present study, it could not be confirmed for all populations.

A correlation between male sterility and flower longevity might be due to the absence of an ethylene peak in male-sterile flowers. This peak normally occurs in male-fertile lily flowers at the end of pollen meiosis as reported for lily 'Enchantment' (Van Meeteren and Slootweg, 1986). Influence of ethylene on longevity of lily flowers has been reported by Woltering and Van Doorn (1988) and Van der Meulen-Muisers and Van Oeveren (1990). Deviating results might be due to the fact that male-sterility and flower distortion often seem to be linked in lily breeding (Wadekamper, 1977). Therefore, other factors concerning flower development might also be involved in determining flower longevity in male-sterile flowers.

The results showing high correlations between offspring and their corresponding parental genotypes in several quality characters indicate that breeding may promise considerable improvement in these quality traits. However, it should be taken into account that deviating results might be obtained due to specific parental combinations (e.g., flower longevity in tulip) or in case of a stronger influence of one of the parents (e.g., male-sterility in lily; stem elongation in tulip). Furthermore, the absence of high correlations between the quality characters tested in both lily and tulip flowers indicate that in many cases we have to work with plants which contain only one or part of the quality characteristics we want. This in combination with the large segregation of individual quality characters within populations might lead to less favourable selection results than might be expected on the basis of the parental genotypes used. Selection in favour of a specific character might at the same time lead to selection against other desirable characters.

It must be realized that the postharvest development of the cut lily or tulip flower is only a small part of the many characters that must be integrated into a breeding programme. Breeding for single objectives, like extended flower longevity, number of floral buds, reduced postharvest stem elongation or absence of pollen can only be successful if these traits are finally combined with the other traits the grower requires for his market.

Acknowledgements

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