Temperature and Quality in South African Bulb Production©

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INTRODUCTION

Floriculture is emerging as a high-value industry in many sub-Saharan economies where it contributes to creating employment and generating foreign exchange (World Bank, 1996). The flower bulb industry as a sector of the floriculture industry comprises two subsectors, namely dry bulb sales directly for the public and bulbs for the so-called "forcing sector" (production of cut flowers and potted bulbs under controlled conditions). Because flower bulbs have an important share in the floriculture industry, and the worldwide demand (sales) for cut flowers and potted plants rise by about 3% to 5% annually, forcing of bulbs became an important industry (Kleijn and Heybroek, 1992).

NEW CROP DEVELOPMENT IN SOUTH AFRICA

Development of a new crop includes a combination of superior plant material, production technology, and marketing strategies. Regarding production technology, research results are limited and accurate information on the temperature to be used for optimal bulb production as well as for the cultivation of high quality pot plants is not available.

Plant Characteristics. *Lachenalia,* endemic to South Africa, can be used in the floriculture industry for potted plants and cut flowers as well as garden bulbs for the following valuable characteristics (Hancke, 1991): Large variation in appearance exists within the genus; the genus has a long flowering period from May to September; the flowers of the inflorescence are long lasting, from 4 to 6 weeks; the plants can be propagated vegetatively without problems. This can be done by means of bulblet production from leaf cuttings, spontaneous daughter bulbs, and bulblet formation from active growing bulb and tissue culture; and the plants have a low temperature and light requirement during the active growing season. *Lachenalia* thus has a low energy requirement thereby reducing production costs. In addition to Hanke's (1991) list of characters, the fact that the bulbs can be removed from the substrate and stored makes postharvest handling and physiological manipulation much easier for the grower.

Production System. The main production areas for *Lachenalia* are situated in the summer rainfall region, which is in the proximity of the majority of flower and bulb growers in South Africa. At present the production of the bulbs is done under shade net and plants are grown in a composted bark mixture. The production system consists of four phases (Fig. 1) that differ distinctly, namely:

1) Bulblet production from cuttings followed by a dormant phase.
2) Bulb enlargement followed by a dormant phase.
3) Bulb preparation followed by a dormant phase.
4) Pot plant production.

The objective of Phase 1 is to propagate disease-free bulbs by means of leaf cuttings under outdoor conditions and in tissue culture. Bulbs obtained from Phase 1, that are too small for the bulb preparation phase (Phase 3), are grown for another season (Phase 2) to reach a bulb size of 4 to 5 cm in circumference (± 1 g). The objective of Phase 3 is to obtain a maximum bulb size of 5 to 6 to 9 cm in circumference, coupled with a good keeping quality to ensure that high quality pot plants will be obtained during the next season (Phase 4), following an extended dormant period. The objective of Phase 4 is to produce a uniform, high quality crop with a good shelf life within the shortest possible period with the lowest inputs. After this phase the mother bulb tends to decrease in size or break up in daughter bulbs, whilst the daughter bulbs grow independently into different sizes. Normally the bulbs of these pot plants, which are sold to the consumer, are planted in their gardens. If not sold, these bulbs are then taken up in the production system and grouped into different production phases according to their size.

During storage periods the dormant bulbs are cleaned, stored in flat trays and stacked in well-ventilated rooms at a relative humidity (RH) of 60% to 70%. Storage temperatures vary according to the ultimate use of the bulbs (Fig. 1). Phase 1 and Phase 2 bulbs are stored at 25 °C until planting for the next phase and Phase three bulbs, which have been prepared for the pot-plant phase (Phase 4), are stored at different temperatures. Soon after harvest, Phase three bulbs are stored at 35 °C for ±14 d to ensure a uniform crop the next season (Phase 4) (Louw, 1991). After this high temperature storage, the bulbs are stored at 25 °C until required stage for flower differentiation and then they are stored at 13 °C for 2 weeks to enhance flower development before planting (Louw, 1991; Niederwieser et al., 1997).

Research Program. The *Lachenalia* research program at ARC-Roodeplaat started in 1965 and has gone through several evolutionary phases (Niederwieser et al., 1998), namely from 1965 to 1972; the focus was on developing procedures and techniques for maintenance and storage of bulbs, growing conditions, hybridization, pollen storage, seed germination, seedling growth, as well as the propagation of *Lachenalia.* From 1972-82, the major emphasis of the program was on the production of hybrids. From 1983-91, less emphasis was directed to breeding, but more effort was put on the initiation of trials abroad and the establishment of an international network to introduce *Lachenalia* to the international flower bulb market. The most significant achievement during this period was the development of tissue culture techniques for producing virus-free planting material.

From 1992 to date, a multi-disciplinary research program was established to intensify efforts to commercialize the *Lachenalia* production. Priorities were focussed on flower manipulation studies, optimal temperature for pot plant cultivation, elimination of the virus-infected plants, developing hybrid evaluation systems, production of propagation materials, and trials on vegetative propagation methods.

The aim of this paper is to highlight significant research that was achieved at the University of Pretoria. With above-mentioned research, bulb growth was determined during the bulb preparation phase (Year 1) and subsequently the morphology of the bulb was evaluated during the pot-plant phase (Year 2).

TEMPERATURE EFFECTS

Bulb Preparation Phase. Three temperature regimes, representing the cool [15/5 °C day/night (LTR)], moderate [22 °C day/10 °C night (MTR)], and warm [28 °C day/12 °C night (HTR)] winter climate, were chosen to manipulate bulb growth during the bulb preparation phase (Year 1). The bulbs (4 cm in circumference each) were grown up under above mentioned temperature conditions, then harvested and stored at 25 ºC. Prior to harvest and during storage the stage of flower development of these bulbs was determined. Du Toit et al. (2001a and 2002) described the developmental stage in which the treated bulbs were at 25 ºC before harvest and during the storage period. When the oldest flower of the inflorescence in the bulb was at the G-phase (the three carpel primordia are formed in the oldest floret), the bulbs were then further stored dry for ±14 days at 13 ºC before planting (Louw, 1991). This forcing treatment was recommended by Louw (1991) for further flower differentiation and elongation of the inflorescence inside the bulb as well improving the quality of the inflorescence.

Results and Discussion. With microscopic observations during the bulb preparation phase, it was concluded that *Lachenalia* 'Ronina' has a typical rhythmic, sympodial, modular growth pattern and that the different temperature regimes affected the time of flower differentiation inside the bulbs (Du Toit et al., 2001a,b and 2002). In addition to above mentioned results, the morphological studies during bulb growth, showed that the low (LTR) and moderate (MTR) temperature regime were found to be the best temperature regimes for bulb production. The high (HTR) temperature regime caused bulbs to develop faster, but flower abortion occurred. At the end of the bulb preparation phase, daughter bulbs were observed in the axils of the leaf bases in bulbs of all three temperature regime treatments during storage at 25 °C. Additional inflorescences from underdeveloped growth modules were detected in the axils of the inner leaf bases of bulbs of the HTR. Bulbs subjected to a LTR treatment developed slightly slower than those of the MTR and HTR treatments. However, in spite of the slower development of bulbs subjected to the LTR, the overall quality was better than bulbs grown in the MTR and HTR (Du Toit et al., 2001a and 2002).

Pot Plant Phase. After ±14 days of storage at 13 ºC, bulbs of the HTR, MTR, and LTR, weighing about 5 to 10 g (5 to 9 cm in circumference) each, were all grown up under a 15 °C day/10 ºC night temperature regime. When the oldest flower of the inflorescence opened, the pot plant was transferred to a growth cabinet that provided a constant temperature of 22 ºC to simulate office conditions. The flowering date, quality, and shelf life of these pot plants were then investigated.

Results and Discussion. The LTR-treated bulbs produced inflorescences with the longest keeping ability and simultaneous flowering was noticed. The lower the temperature regime during the bulb preparation phase the greater the peduncle length, rachis length, floret number as well as the peduncle diameter of the primary, secondary and tertiary inflorescences. MTR- and LTR-treated bulbs produced more inflorescences than the HTR-treated bulbs. Finally, the LTR-treated bulbs produced broader leaves than the MTR- and HTR-treated bulbs.

CONCLUSION

The cool winter climate would be optimal for the bulb preparation phase to produce a quality bulb and consequently a quality pot plant the following year. It is also clear that bulbs produced under different climatic conditions will not necessarily be in the same physiological state, even if they are harvested on the same date. Another important observation is that these bulbs are normally not physiologically

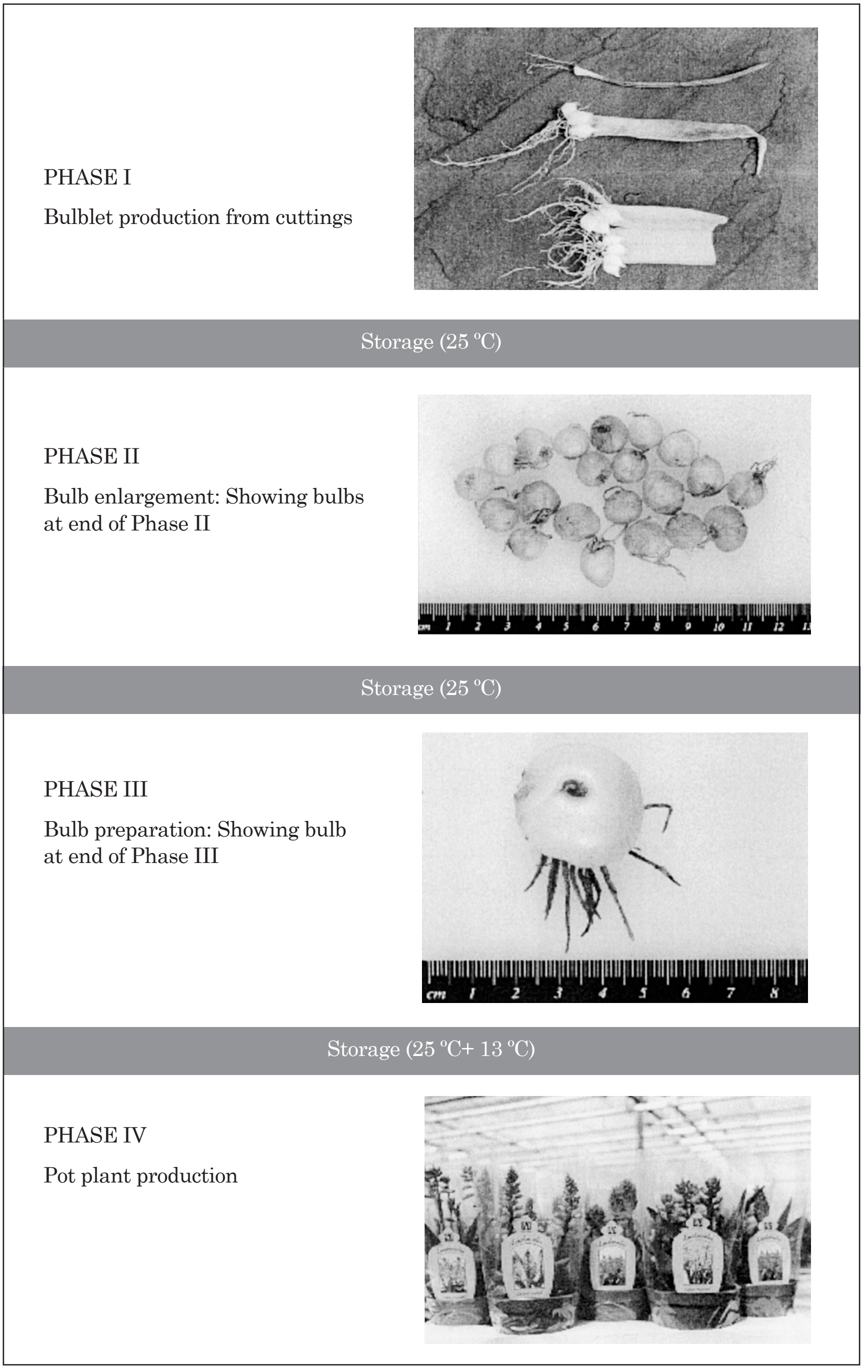

Figure 1. Schematic illustration of four production phases of *Lachenalia*.

at rest. A study that should be considered is to manipulate the annual growing cycle of a *Lachenalia* bulb to an evergreen plant, which will produce flowers continuously. The growth rate of the modules, emergence of additional inflorescences from underdeveloped modules, daughter bulb development as well as flower abortion are therefore important factors that need to be considered. The mapping of bulb development in terms of modular growth could be a valuable tool for comparing bulb development under different conditions.

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