Effect of temperature on the growth of *Lachenalia* cv. Ronina during the bulb preparation phase

E.S. du Toit[1]*, P.J. Robbertse[1] and J.G. Niederwieser[2]

[1]Department of Plant Production and Soil Science, Faculty of Natural and Agricultural Sciences, University of Pretoria, Pretoria 0002, Republic of South Africa

[2]ARC-Vegetable and Ornamental Plant Institute, Roodeplaat, Private Bag X 293, Pretoria 0001, Republic of South Africa

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Lachenalia cultivars have excellent characteristics as flowering pot plants. The effect of three temperature regimes on the growth of small bulbs of *Lachenalia* cv. Ronina to flowering size (± 7 g) was studied. Potted bulbs were grown in three temperature controlled cabinets with temperature regimes chosen to represent a cold, a moderate and a warm winter. Plants were destructively harvested to investigate environmental effects on plant morphology and additionally flowering, anthesis and flower senescence were monitored. Under all three temperature regimes bulb growth followed a typical sigmoidal curve. Root growth does not support optimal bulb size under the different temperature regimes. Leaf growth in plants under the moderate temperature regime was more vigorous and foliage had a healthier appearance than in the low and high temperature regime treatments. Inflorescence emergence was earlier under the low and moderate temperature regime. At the end of the growing season, bulbs grown in the high temperature treatment formed secondary inflorescences. The best temperature regimes for *Lachenalia* bulb production were the low and moderate temperature regime which represented the cool and moderate winter climate in South Africa.

Keywords: Hyacinthaceae, bulbs, pot plants.

* To whom correspondence should be addressed, (E-mail : edutoit@postino.up.ac.za).

Introduction

Lachenalia cv. Ronina is a variety with excellent characteristics as a flowering pot plant (Coertze, Hancke, Louw, Niederwieser & Klesser, 1992; Niederwieser, Anandajayasekeram, Coetzee, Martella, Pieterse & Marasas, 1997). Increased production and export of *Lachenalia* bulbs may help South Africa increase its share in the international bulb trade. To improve production and growing of bulbs, information is needed on the effect of climatic factors on growth and yield of bulbs as South Africa has tremendous climatic diversity that ranges from summer to winter rainfall regions, arid to humid zones and temperate to tropical areas. Additionally there is much variation both in and between *Lachenalia* species that may also include optimal growing conditions. *Lachenalia* spp. follow the growth cycle of winter rainfall plants which entails rapid vegetative growth in autumn (April to May), followed by flowering in winter and spring (June to September). Flowering and fruiting is followed by a long dormant period during the hot dry summer months (November to March) (Duncan, 1988).

Temperature is the most important environmental factor in regulating the growth cycle of bulbs in the Hyacinthaceae family to which *Lachenalia* belongs (rees, 1992). In contrast, day length has little effect. For *Lachenalia* the effect of temperature has been studied on long term *in vitro* storage of vegetative material (Louw, 1992), *in vivo* bulb storage for successful flower forcing (Louw, 1991) and *in vitro* bulblet formation (Slabbert & Niederwieser, 1999). The effects of temperature on the growth and flowering of *Lachenalia* during the growing season have not been reported previously (De Hertogh & Le Nard, 1993; Roodbol & Niederwieser, 1998).

The objective of this study was to determine the effect of three temperature regimes on the growth and development of bulbs during the growing season. As this was the first study of its kind, temperature regimes were chosen to represent a cold, a moderate and a warm winter climate. This experiment was repeated for two consecutive seasons with very similar results. For practical reasons, only the second year's results are reported in this article.

Materials and Methods

Bulbs of *Lachenalia* cv. Ronina were obtained from the Agricultural Research Council's *Lachenalia* breeding programme. The 1200 bulbs weighed about 1g each and were received after approximately four months storage at 25°C.

The bulbs were planted singly into 9 cm plastic pots containing sterilized, composted bark. On the first of March 400 pots containing the bulbs were placed into each of three growth cabinets (Model PGW-36, Conviron, Canada). The growth cabinets provided a 14 hr photoperiod with a light intensity of ± 200 μmol m^2 s^{-1} PAR at plant level. Lighting was provided by a combination of WHO fluorescent and incandescent bulbs. Each growth cabinet was adjusted to provide a different temperature regime as described in Table 1. The temperature regimes were chosen to represent a cool (LTR), a moderate (MTR) and warm (HTR) winter climate.

The plants were watered to field capacity three times a week using distilled water except for the high temperature treatment in which plants were watered daily, because signs of water stress had been observed in a preliminary trial watered three times a week. From the fifteenth of August till the fifteenth of October watering frequencies in the cabinets were gradually reduced to simulate the onset of the dry summer season and to force the bulbs into dormancy.

The four hundred bulbs in each cabinet were randomly divided into ten replicates of 40 plants. On the fifteenth of every month during the growing season, one plant from each

Table 1 Temperature regime treatments (°C) during the bulb preparation phase

	High Temperature Regime (HTR)		Moderate Temperature Regime (MTR)		Low Temperature Regime (LTR)	
Duration	Day	Night	Day	Night	Day	Night
1 March–15 June[1]	28	12	22	10	15	5
15 June–15 July[2]	28	12	22	10	20	10
15 July–15 August	28	12	27	15	25	15
15 August–15 October[3]	33	17	32	20	30	20
15 October–15 November[4]	35	35	35	35	35	35

[1]Foliage emergence
[2]Full-flowering (Anthesis)
[3]Foliage and Inflorescence senescence
[4]Bulbs were dormant

replicate (10 plants per cabinet) was selected at random and dissected into bulbs, roots, leaves and inflorescence (when visible), after which the fresh mass of each portion was determined. Previous trials had shown very high correlations between fresh and dry mass of bulbs, leaves and roots. The percentage of plants with inflorescences at different stages of development (emergence, anthesis and senescence) was determined for the three temperature regimes.

Data were analysed using the PROC. G.L.M. (General Linear Models) procedure in the S.A.S. (Statistical Analysis System) program. Analysis of Variance was performed and Tukey's studentized range test (Steele & Torrie, 1980) was applied to compare treatment means.

Results and Discussion

The fresh mass of the various parts of the plants grown under the three temperature regimes are shown in Figure 1. Table 2 gives results on the effect of three temperature regime treatments on the percentages of inflorescences during emergence, anthesis and senescence.

Bulb growth

Bulb growth followed a typical sigmoidal curve up to flowering, irrespective of the treatments (Figure 1a). Similar results were reported by Roodbol and Niederwieser (1998) on *Lachenalia* cv. Romelia grown under moderate winter conditions. After flowering (June–July), further increases in bulb mass coincided with flower senescence. In all treatments,

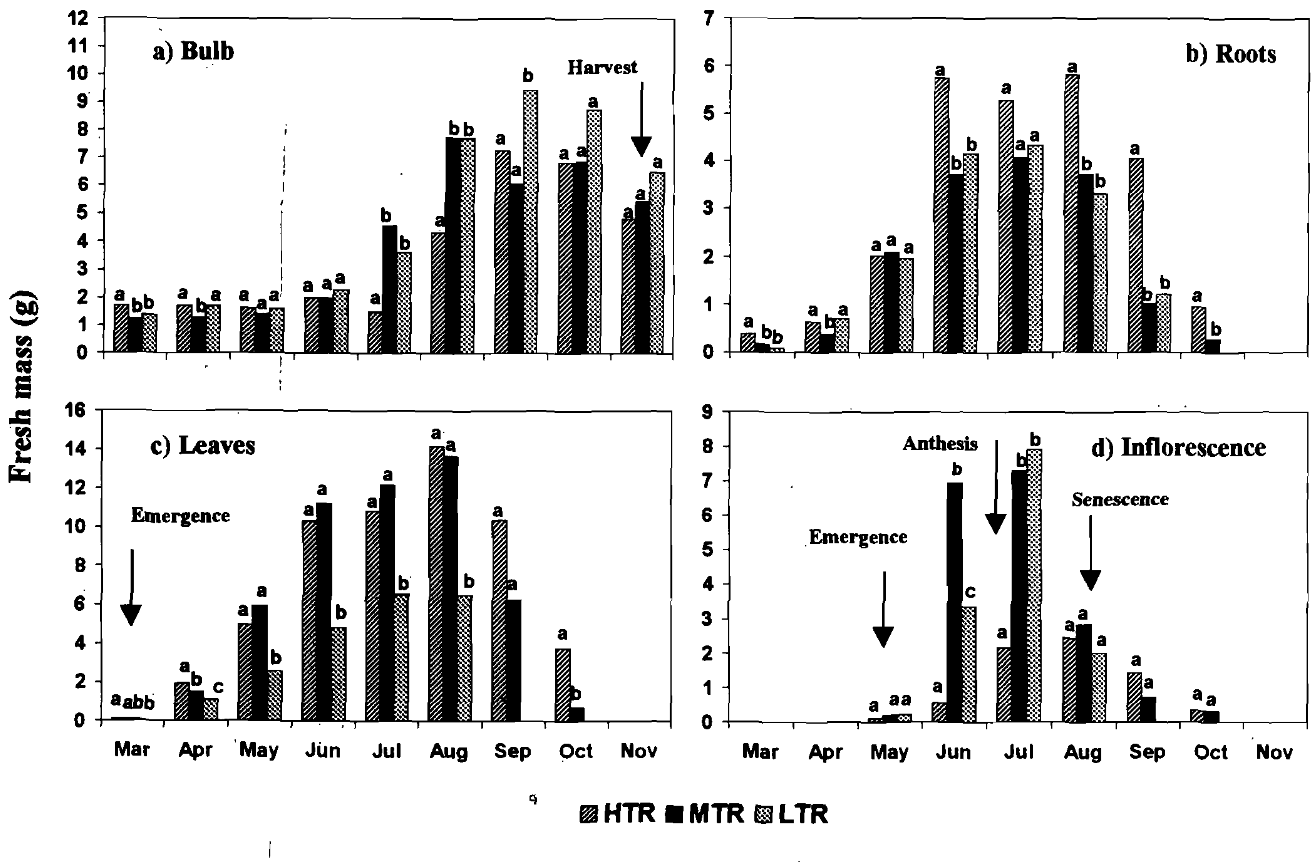

Figure 1 Monthly effect of three temperature regime treatments on the growth of *Lachenalia* cv. Ronina.

Table 2 Effect of high (HTR), moderate (MTR) and low (LTR) temperature regime on the percentages of *Lachenalia* cv. Ronina inflorescences during emergence, anthesis and senescence

		Temperature regimes		
Months	Stage	HTR[d]	MTR[e]	LTR[f]
	Emergence[a]	90	100	100
May	Anthesis[b]	0	0	0
	Senescence[c]	0	0	0
	Emergence	100	10	60
June	Anthesis	0	90	40
	Senescence	0	0	0
	Emergence	30	0	0
July	Anthesis	60	20	40
	Senescence	0	80	60
	Emergence	50*	0	0
August	Anthesis	0	0	0
	Senescence	70***	100	100
	Emergence	0	0	0
September	Anthesis	20**	0	0
	Senescence	100	100	100
	Emergence	20*	0	0
October	Anthesis	0	0	0
	Senescence	100	100	100

[a]Inflorescence visible above soil.
[b]Oldest flower of the inflorescence opened.
[c]50% of the flowers of the inflorescence wilted.
[d]High temperature regime treatment.
[e]Moderate temperature regime treatment.
[f]Low temperature regime treatment.
*Percentage of secondary inflorescences emerged.
**Percentage of secondary inflorescences at anthesis.
***Inflorescence abortion occurred.

bulb mass continued to increase until late August to September, in spite of the watering frequency being reduced from the 15th of August. This phenomenon is probably a result of translocation of assimilates from the leaves that started senescing during August. Rees (1992) supports the concept that assimilates produced by the aerial parts of the plant during the active growing season are translocated to the storage organs until the aerial parts die down.

Bulbs from the LTR became dormant one month earlier (October) than those from the HTR and MTR as indicated by the absence of roots and leaves in the LTR plants in October (Figure 1b and c). The low temperature regime initially reduced the developmental rate of the different plant parts, but subsequently resulted in a faster development (earlier plant maturity), which is an inducing effect of a low temperature treatment.

Bulb fresh mass decreased from October to November (Figure 1a). This was probably due to moisture loss caused by the high temperature treatment (35°C) during the storage of the dormant bulbs (Table 1).

Significant differences in bulb size between the three temperature treatments were obtained at the end of the bulb preparation phase. Figure 1a illustrates that the final bulb fresh mass of the LTR was greater than those of the HTR and MTR. It seems as if bulbs of the LTR performed the best in terms of bulb size but only until September. After September there is no significant difference between the HTR, MTR and LTR bulbs.

Root growth

Root mass is shown in Figure 1b. The fresh mass of the roots increased for the first four months in all treatments. The roots maximum fresh mass was reached between July and August and coincided with the leaves reaching their maximum biomass (Figure 1c) and the plants reaching full-bloom (Figure 1d). After full bloom the fresh mass of the roots decreased rapidly as the plant became senescent. After full-bloom the maximum root fresh mass of HTR plants was almost always significantly greater than the other treatments and declined more slowly. This indicates that exposure to high temperatures for a long period promoted root growth. This observation confirms the results of similar studies done by Le Nard (1980) on tulips and Jennings and De Hertogh (1977) on tulips, daffodils and hyacinths. For the commercial grower, these results reflect that optimal root growth during the production phase does not necessarily promote the final bulb size.

Leaf growth

Leaf fresh mass increased until August in all treatments (Figure 1c) after which the leaf fresh mass declined. There were obvious morphological differences between the leaves of different temperature treatments. The MTR leaves were robust, broad, lanceolate, upright and healthy. Leaves of the HTR were long, narrow and curved, whereas leaves of the LTR were prostate and broad. These results show that the MTR leaves grew more vigorously and appeared more attractive than those of the LTR and HTR for much of the year.

Whole plant growth

The LTR resulted in a significantly lower fresh mass of aerial leaf parts and also of roots, but it had a positive effect on bulb growth. The low fresh mass could primarily be due to diversion of food reserves from aerial leaf parts and roots to the bulbs for enlargement, thus preventing optimal leaf and root growth of LTR bulbs. Le Nard and Cohat (1968) also reported that, depending on the duration of a cold treatment, root growth and elongation of aerial organs can be retarded in *Tulipa*. The only growth process which takes place is then bulb growth.

Growth of inflorescences

During peak flowering (June to July), the fresh mass of the MTR and LTR inflorescences were significantly higher (Figure 1d) than those of the HTR. The reason for the lower fresh mass of the HTR bulbs was that they produced a shorter peduncle and rachis and floret abortion occurred. There is evidence in literature confirming that high temperature extremes effect inflorescence quality negatively (De Hertogh & Le Nard, 1993). During August, September and October, secondary inflorescences were observed in the HTR bulbs (Table 2) and it seems as if the warm temperature regime induced the initiation of secondary inflorescences. Louw (1991) found a similar effect with *Lachenalia* cv. Romelia bulbs when stored under a high temperature for a long period.

MTR and LTR inflorescences emerged earlier than those of the HTR (Figure 1d and Table 2). Thus, when 25°C dry-stored bulbs were planted under an extended high temperature regime (HTR - 28°C/12°C), there was a delay in flower bud differentiation. But, when these bulbs were subjected to lower temperatures (MTR - 22°C/10°C; LTR - 15°C/5°C), earlier flower bud differentiation was observed. Similar results were reported by Le Nard (1972) and Beijer (1942) in tulips, where a high storage temperature (30°C) followed by a transfer to a lower temperature (20°C) resulted in an earlier flower bud differentiation. Roh and Meerow (1992) also stated that temperature plays an important role in inducing early flowering of *Eucrosia bicolor* bulbs. Gilford and Rees (1973) and Shoub and De Hertogh (1975) on the other hand, hypothesized that the lower flower shoot growth rate observed immediately after planting could be related to root growth and the possible fact that food reserves are diverted from the shoot and scales to the roots.

Although flower initiation and differentiation, according to Louw (1991), had taken place during storage before planting, different temperature regimes during the bulb preparation phase affected the development rate of the inflorescence with higher temperatures striving the rate of appearance of the inflorescence.

Conclusions

For the potential farmer, bulbs of a commercial flowering size (± 7 g fresh mass) can successfully be grown under moderate and low temperature regimes which represent the cool and moderate winter climate in South Africa. Regions with a warm winter climate are probably unsuitable for *Lachenalia* production as bulb yield was reduced under the HTR in our study. It is also apparent that temperatures to which the bulbs are subjected during their enlargement can affect their physiological state at harvest.

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