2) Mechanisation issues:
- Tray filling and potting machine combination.
- Seed sowing machine and plug production.
- Trolley and crate system to transport plants.
- Truck with tailgate lift.
- Irrigation systems.
- Computerised accounting, production planning, and labelling.

3) Labour performance issues:
- Emphasise on teamwork.
- Skills training to complete various processes effectively.
- Employ people according to their abilities and treat them fairly.
- Employees are encouraged to take responsibility.

4) Nursery layout issues:
- Lessons learned from the past.
- Advantages of the layout of the new section.

5) Customer service issues:
- Delivery up to point of sale.
- All products pre labelled and priced.
- Cash and carry customer convenience.

Manipulation of Flowering in Clivia©

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INTRODUCTION

The genus *Clivia* Lindl. belongs to the family Amaryllidaceae and comprises four species, all endemic to Southern Africa. Three of the species, *C. caulescens* R. A. Deyer, *C. gardenii* Hook., and *C. nobilis* Lindl. have tubular, pendulous flowers, while *C. miniata* Lindl. Regel have erect, trumpet-like flowers. The latter species is the most widely cultivated as a garden or pot plant and is, therefore, also the most researched of the four species. In this talk I will concentrate on the flowering of *C. miniata.*

The flowering period o*f C. miniata* is in early spring and under South African conditions peaks in August-September although it is possible to manipulate the flowering period to some extent by regulating the growing temperature (Mori and Sakanishi, 1974; De Smedt et al., 1996; Honball, 2001) and lighting (Vissers and Haleydt, 1994). Before attempting to manipulate flowering in any plant, however, it is important to have a thorough understanding of the growth model of the plant and in this talk it will be treated as one of the major aspects.

GROWTH MODEL

A *Clivia* plant raised from seed, has a single axis consisting of a true stem-part covered with the closely spaced leaf sheaths forming a pseudostem. Figures 1A and 1B show a longitudinal section of the stem apex of a *Clivia* plant showing the apical bud and next to it a young inflorescence bud. After having observed the growth and

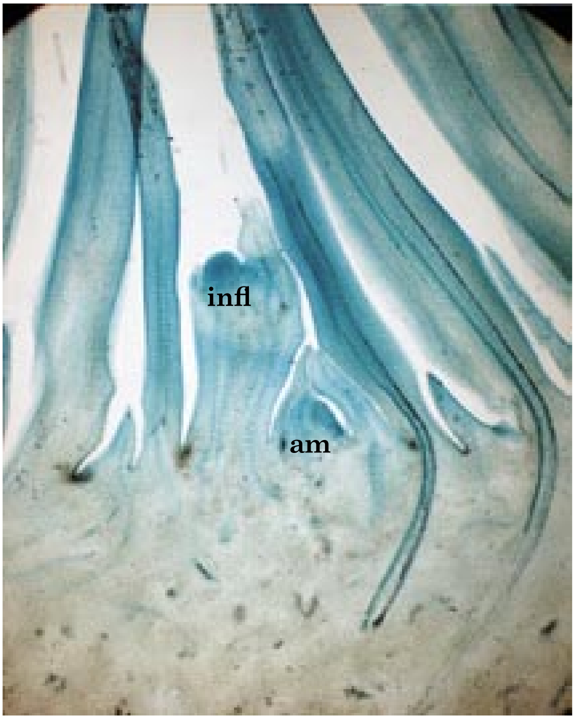

Figure 1A. Longitudinal section of clivia stem showing inflorescence bud (infl) and new apical bud (am).

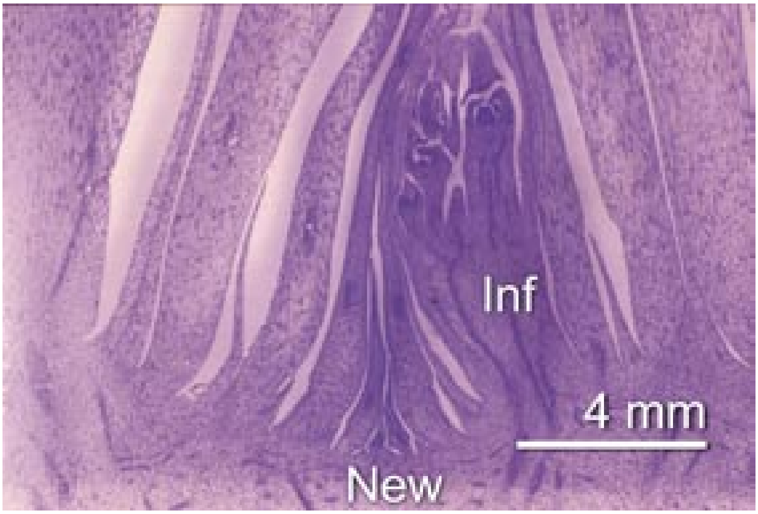

Figure 1B. Longitudinal section of clivia stem showing more advanced stage of inflorescence bud (inf) and new apical bud (new).

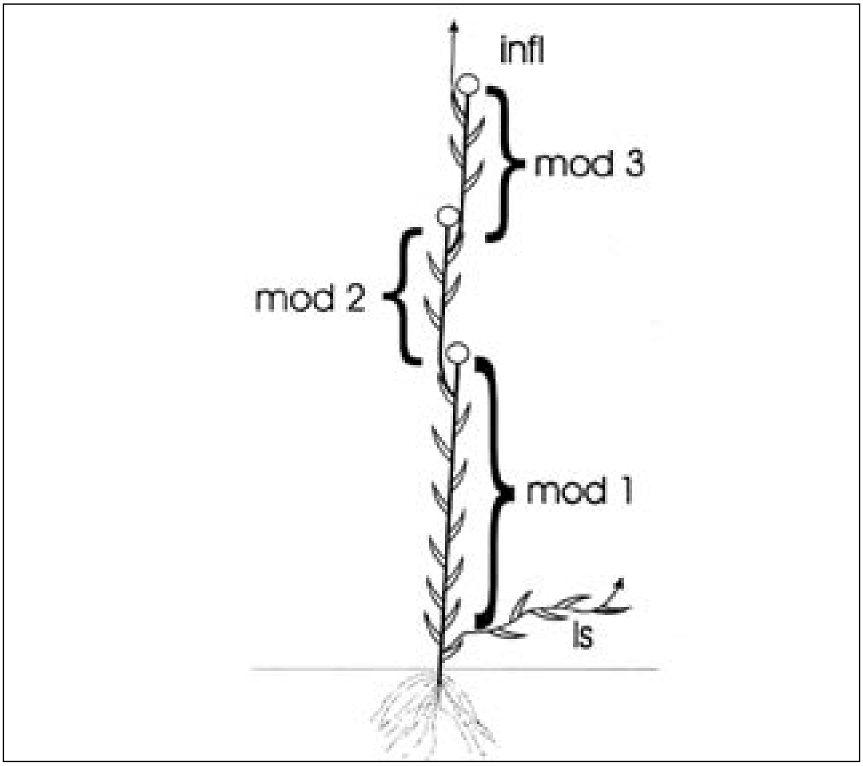

Figure 2. Growth model of *Clivia miniata.* mod 1 = first module, representing the juvenile phase with twelve leaves and an inflorescence; mod 2 and 3 = second and third modules, each with four leaves and a terminal inflorescence bud (infl); ls = basitonic, lateral shoot (offset).

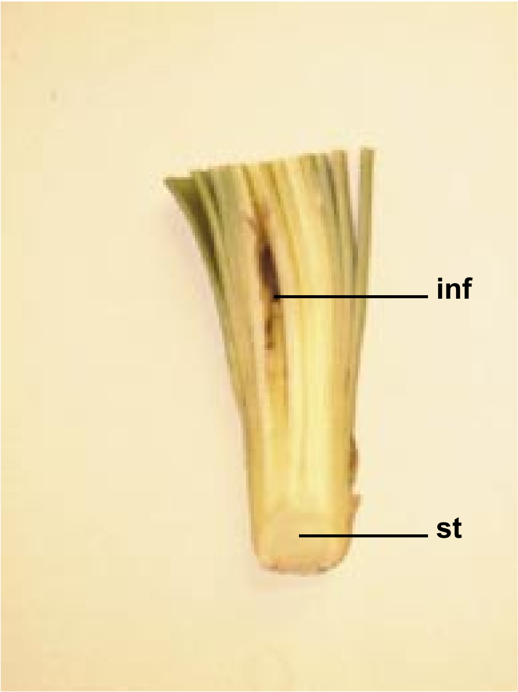

Figure 3. Longitudinal section of clivia stem, showing the true stem (st), the pseudo-stem consisting of leaf sheaths and an aborted inflorescence bud (inf).

Figure 4. Flowering plant, inflorescence without elongated scape, flowers appearing between the leave sheaths.

flowering of *Clivia* plants over a period of years and relating these observations to the structure as depicted in Fig. 1A and 1B, it can be stated that sexually mature *C. miniata* plants have a sympodial, modular growth system.

Plants grown from seed have a juvenile phase of about 3 to 4 years during which phase the growth is monopodial (no branching occur and the terminal bud produces leaves only). After the formation of about 12 to 14 leaves by the terminal bud, the latter is transformed into an inflorescence bud and a new terminal bud arises next to the inflorescence bud (Fig. 1A and B). After a quiescent period, the "new" apical bud produces a flush of about four new leaves before being transformed into the next inflorescence in the same way as its predecessor. The result of such an episode is the formation of one module, consisting of a condensed stem with four leaves and a terminal inflorescence bud. Due to the condensed nature of the stem, the modular parts cannot be distinguished as separate units.

Depending on the environment and nutrition of the plant, two or more of these growth flushes or modules can be produced per season and towards fall, the same axis may therefore consist of a number of modules, each terminating in a semi-dormant inflorescence bud (Fig. 2). The inflorescence buds are imbedded amongst the leaf sheathes of the pseudostem-part of the axis and are, therefore, not visible unless the leaf sheaths are torn apart (Fig. 3).

FLOWERING AND MANIPULATION OF FLOWERING

External and internal factors are now required for further development of the inflorescence buds before flowering can occur. It is known that temperature plays a major role in the stimulating flower bud development and scape elongation (de Smedt et al., 1996 and Honibal and Robbertse, 2001). After flower bud initiation, bud development and scape elongation do not stop completely but slows down drastically, with the result that in the same plant or shoot, the first-formed inflorescence buds, the flower buds are in a more advanced stage of development and the scapes are longer compared to those of later-formed inflorescence buds (De Smedt et al., 1996). Although not yet experimentally proven, it seems as if flower bud development proceeds slowly in the semi-dormant inflorescence buds and flowering will eventually occur with or without scape elongation once the flower buds have reached a certain developmental stage. Scape elongation, on the other hand is dependent on a preceding chilling period (Honniball and Robbertse, 2001). The age of the inflorescence bud and the scape seems to be an important factor determining the receptivity of the scape for the chilling or vernalizing effect. The result is that only inflorescence buds, which have reached a minimum age, will be receptive to the chilling. In the absence of a chilling period, out-of-season flowering will occur in those inflorescence buds in which the flower buds have reached the stage where anthesis (opening of the flowers) can no longer be postponed. This will lead to flowers appearing amongst the leaves without scape elongation (Fig. 4). This phenomenon was observed in plants that were grown in a greenhouse for a period of 3 years at a temperature regime of 20 to 30°C. These plants flowered sporadically right through the year and most of the inflorescences were without elongated scapes as depicted in Fig. 4. In some cases the flower buds aborted as shown in Fig. 3. Exceptions, however, did occur where some of the inflorescences did have elongated scapes, showing that other factors like nutrition, water stress, high temperatures or a slight drop in temperature might also be involved in triggering scape elongation. Although the main flowering period is just prior to, or during the spring equinox, flowering often also occurs during the autumn equinox, but then mostly with un-elongated scapes. Much more research is, however, needed to solve the mystery.

CONCLUSION

Judging from the present knowledge, it is clear that *C. miniata* inflorescence buds are formed spontaneously due to the sympodial, modular growth of the plant. Chilling of at least 10 days at about10°C is required for triggering scape elongation prior to flowering. The inflorescence bud, and more specifically the individual flower buds, must have reached a minimum developmental stage in order for the scape to be receptive for the chilling treatment. In most cases only one inflorescence bud per branch (axis) has reached this stage at the end of the growing season, thus producing only one inflorescence during spring. In the case of more vigorous plants, more than one inflorescence can be produced during the same flowering period. Plants can be manipulated to flower out of season and more than once per year by subjecting them to chilling conditions as mentioned above.

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