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Estimating the phyllochron in lily (*Lilium longiflorum* Thunb.)

Estimativa do filocrono em lírio (*Lilium longiflorum* Thunb.)

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***Abstract** - Lily is an important flower in the world flower market. Estimating the phyllochron (the time interval between the appearance of successive leaves) is important for calculating the number of emerged leaves (NL) on the plant, which is an excellent measure of plant development. The objective of this study was to estimate the phyllochron in lily (Lilium longiflorum Thunb.). Three experiments were conducted at Santa Maria, RS, Brazil, inside an 8 x 15 m plastic greenhouse and in the field, during 2002 and 2003. The "Snow Queen", a white-flower lily cultivar was used. Main stem NL was measured twice a week. Daily growing degree-days above a base temperature (1°C) and accumulated thermal time (TT) were calculated. The NL was linearly regressed against TT. The phyllochron (°C days/leaf) was estimated by the inverse of the angular coefficient of the linear regression. The average phyllochron of the "Snow Queen" lily was 19.1 ± 4.2°C days/leaf.*

***Key words**: phyllochron, leaf appearance, thermal time, lily.*

***Resumo** - O lírio é uma importante flor comercializada no mercado de flores em todo mundo. A estimativa do filocrono (tempo necessário para o aparecimento de folhas sucessivas) é importante no cálculo do número de folhas emergidas (NL) na planta, o qual é uma excelente medida de tempo vegetal. O objetivo deste trabalho foi estimar o filocrono em lírio (Lilium longiflorum Thunb.). Foram conduzidos três experimentos em Santa Maria, RS, no interior de uma estufa plástica de 8 x 15 m e a campo, nos anos de 2002 e 2003. Foi utilizada a cultivar "Snow Queen", um lírio branco. O NL na haste principal foi medido duas vezes por semana. Foram calculados o número de graus-dia diário acima de uma temperatura base (1°C) e a soma térmica acumulada (TT). Foi realizada uma análise de regressão linear entre NL e TT. O filocrono (°C dia/folha) foi estimado pelo inverso do coeficiente angular da regressão linear. O valor estimado do filocrono do lírio "Snow Queen" foi 19,1 ± 4,2°C dia/folha.*

***Palavras-chave:** filocrono, aparecimento de folhas, soma térmica, lírio.*

Introduction

Lily (*Lilium longiflorum* Thunb.) is one of the six more important genera of flower bulbs produced worldwide (DE HERTOGH & LE NARD, 1993). The importance of this genus in the world flower market is in large part due to the diversity of the species and the large number of hybrids and cultivars commercially available (DE HERTOGH, 1996). Major markets for lily include fresh cut flowers, potted flowering plants, and gardens and landscapes (DE HERTOGH, 1996; GRASSOTTI, 1996; MYNETT, 1996).

The calculation of the rate that leaves become visible on a stem is an important component of many

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crop simulation models (WEIR et al., 1984; RITCHIE, 1991; SHAYKEWICH, 1995; WANG & ENGEL, 1998). The phyllochron, defined as the time interval between the appearance of successive leaves (KLEPPER et al, 1982; KIRBY, 1995), has been widely used to calculate the number of emerged leaves (NL) on the plant main stem, which is an excellent measure of plant development (RITCHIE, 1991; RICKMAN & KLEPPER, 1991; McMASTER et al., 1991). The main stem NL is related to tiller appearance in some species such as wheat (KLEPPER et al., 1982) and to the timing of certain key developmental stages in several species including lily (FISHER et al., 1997a,b). Accurately calculating the appearance of individual leaves and the rate of leaf area expansion also has an impact on calculating light interception and absorption by the canopy, canopy photosynthesis, and therefore, accumulation of dry matter and yield (AMIR & SINCLAIR, 1991; HODGES & RITCHIE, 1991; McMASTER et al., 1991).

When using the concept of phyllochron, time can be expressed as thermal time (TT), measured in units of degree-days (°C day). Thermal time is a better time descriptor in plants than day of the year and number of days after sowing (GILMORE & ROGERS, 1958; RUSSELE et al., 1984; McMASTER & SMIKA, 1988). In this case, the phyllochron is the number of degree-days for each leaf to appear (°C days/leaf). The objective of this study was to estimate the phyllochron in lily.

Material and methods

Three experiments were carried out at the Federal University of Santa Maria (UFSM), Santa Maria, RS, Brazil (latitude: 29°43'S, longitude: 53°48'W and altitude: 95m). The cultivar used in all experiments was the "Snow Queen", a white-flower, well accepted in lily the flower market.

The first experiment was conducted inside an 8 x 15 m plastic house. Bulbs were fully vernalized at 4 and 10°C during 6 and 8 weeks and planted on 05 December 2002. The experimental design was a randomized complete block design with three replications. Each replication was composed by three rows of plants, with 4 plants/row. Plant spacing was 0.15 m between rows and 0.15 m between plants.

In the second experiment, bulbs were vernalized at 0.5°C during two months and planted on 15 May 2003 inside an 8 x 15 m plastic house. The experimental design was a randomized complete block design with seven replications. Each replication was composed by five rows of plants, with 5 plants/row. Plant spacing was 0.15 m between rows and 0.15 m between plants.

In the third experiment, bulbs were also vernalized at 0.5°C during two months and planted on 22 October 2003 both inside an 8 x 15 m plastic house and in the field. The experimental design was a randomized complete block design with four replications. Each replication was composed by five rows of plants, with 5 plants/row. Plant spacing was 0.15 m between rows and 0.15 m between plants.

In all three experiments, plants were well fertilized and well watered. Three to five plants, depending on the experiment, located in the center rows of individual replications were randomly selected and tagged with colored wires after emergence. These plants were used to measure the visible main stem NL twice a week.

Daily minimum and maximum air temperature were recorded inside the plastic house at 1.5 m height with a thermograph (first experiment), and with a mercury-in-glass thermometer (second and third experiments). In the field (third experiment), these meteorological variables were measured in a conventional weather station located at about 200 m from the trial. The daily mean temperature (Tmean) was calculated as the average of the daily minimum and maximum temperatures.

Daily growing degree-days (GDD) were calculated as (GILMORE & ROGERS, 1958; ARNOLD, 1960):

$$GDD = (Tmean - Tb) \cdot 1 \text{ day} \qquad \{^{\circ}C \text{ day}\} \qquad (1)$$

where Tb is the base temperature for leaf appearance rate in lily, assumed 1°C (FISHER et al., 1997a,b). Accumulated thermal time (TT) from emergence was calculated by:

$$TT = \Sigma GDD \qquad \{^{\circ}C \text{ day}\} \qquad (2)$$

The NL was linearly regressed against TT. The phyllochron (oC days/leaf) was estimated by the inverse of the angular coefficient of the linear regression (KLEPPER et al, 1982; KIRBY, 1995).

Results and discussion

There was a strong relationship (R^2=0.97 or greater) between NL and TT in all experiments. An example of this relationship and how the phyllochron was calculated is presented in Figure 1. The strong relationship between NL and TT agrees with previous reports that thermal time is a good measure of physiological time in plants (GILMORE & ROGERS, 1958; RUSSELE et al., 1984; McMASTER & SMIKA, 1988).

The phyllochron of the "Snow Queen" lily was, on average, 19.1 ± 4.2 °C days/leaf (Table 1). Note that the estimated phyllochron was slightly higher in the first and second experiments (21.8 °C days/leaf and 23.1°C days/leaf) than in the third experiment, where plants grown in the field had a slightly greater phyllochron (17.4 °C days/leaf) than the phyllochron of plants grown in the plastic house (13.9 °C days/leaf).

A comparison of phyllochron values among species and genotypes help us to understand the different dynamics of leaf appearance among them. In summer field crops with a Tb=10°C, the phyllochron in maize, sorghum, and soybean were 45.2 °C days/leaf (WARRINGTON & KANEMASU, 1983), 51.7 °C days/leaf (MAJOR et al., 1990), and 55.5 °C days/leaf (SINCLAIR, 1986), respectively. However, when thermal time is used to express time in plants, comparisons of growth and developmental parameters based on thermal time should be at the same Tb. Using a Tb=10°C for lily in our third experiment (field grown plants), the phyllochron in this study is 13.2 °C days/leaf, indicating that leaves of field grown lily appear faster than in the field crops.

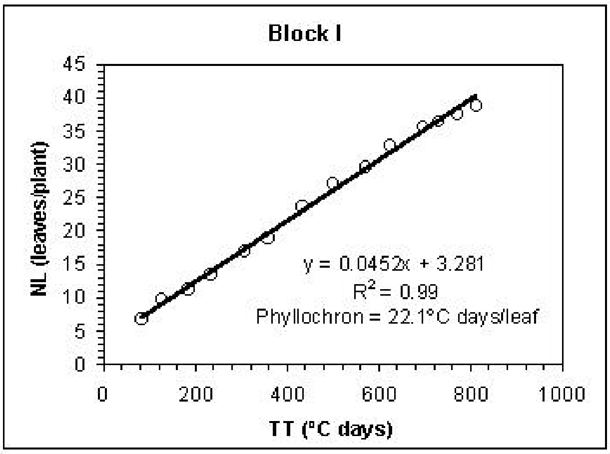

Figure 1. Number of leaves (NL) of the "Snow Queen" lily (*Lilium longiflorum* Thunb.) as a function of accumulated thermal time from emergence (TT) in one replication (Block I) obtained from the second experiment. Santa Maria, RS, Brazil, 2003.

The estimation of the phyllochron is a valuable step towards the development of a model for predicting leaf number and leaf area. FISHER et al. (1997a,b) developed a model for decision support in lily, and number of leaves is an important part of the model. The results obtained in this study will be further used for adjusting the FISHER model to local conditions as our next research goal.

Conclusion

Using thermal time as a measure of plant physiological time and a base temperature of 10°C, leaves of the "Snow Queen" lily took 19.1 °C days to appear.

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Table 1. Estimated phyllochron of the "Snow Queen" lily (*Lilium longiflorum* Thunb.). Santa Maria, RS, Brazil, 2002/2003. The number in parenthesis represents one standard deviation of the mean.

Planting date	Cropping	Phyllochron (°C days/leaf)
05 Dec 2002	plastic house	21.8 (±1.8)
15 May 2003	plastic house	23.1 (±1.3)
22 Oct 2003	plastic house	13.9 (±1.4)
22 Oct 2003	field	17.4 (±1.7)
Mean		19.1 (±4.2)

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