Identification of the Developmental Phases in Poinsettia

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Abstract. Experiments were conducted with poinsettia (Euphorbia pulcherrima [Willd. ex. Klotzsch]) to determine the 1) existence of developmental phases from seedling establishment to flower induction and 2) characteristics that may be used to delineate the phases. The characteristics evaluated were flowering ability, rooting ability, heterophyll, and internode characteristics. Two developmental phases, juvenility and maturity, were identified. The transition between these phases occurred in poinsettias that were 6 to 8 weeks old, following establishment. Mean values for flowering ability, rooting ability, and heterophyll differed for the two developmental phases, rendering them the most useful of the characteristics evaluated for identifying developmental phases in poinsettia.

“Splitting” of poinsettias is an abnormality in which a vegetative shoot tip is transformed into a reproductive bud under long, normally noninductive photoperiods. Usually vegetative shoots develop around the terminal reproductive bud and destroy the desired “single stem”-type growth habit. This phenomenon, first reported in 1964 (Ball, 1985), has gradually increased in occurrence and now is considered a serious problem of poinsettias that may result in significant losses. We postulate that the occurrence of splitting is closely associated with the developmental phases of poinsettia, i.e., the level of juvenility or maturity of stock plant laterals from which cuttings for finished plants are harvested. That is, factors that influence the developmental phase of a stock plant and cutting will also affect the propensity for subsequent splitting of the cuttings. As a first step in testing this hypothesis, a study was designed to determine the existence of developmental phases in the poinsettia, from established seedlings to flower induction, and to identify characteristics that may be used to delineate them.

Developmental phases have been distinguished in other plants by one or more of the following characteristics: flowering ability (Hartman and Kester, 1975; Kester, 1976), rooting ability of cuttings, internode characteristics (Lyrene, 1981), phyllotaxy (Robbins, 1957a, 1957b; Robinson and Wareing, 1969), pigmentation (Robbins, 1957a), horniness (Robbins, 1957b; Robinson and Wareing, 1969), seasonal leaf retention (Hackett, 1983), leaf cuticular characteristics, leaf thickness, shoot orientation, ability to form adventitious roots and buds, partitioning of photosynthates into main stem vs. branches, disease resistance, and cold resistance (Hackett, 1983). Heterophyll (leaf shape) has also proven to be an important indicator of different developmental phases in Marsilea (Allsopp, 1939), Ranunculus (Fisher, 1954), Darlingtonia californica (Franck, 1976), Impomoea c.erulea (Njoku, 1957), and English (Hedera helix) and Algerian ivy (H. algeriensis) (Stoutemyer and Britt, 1961).

In this study, 13 plant characteristics of poinsettia were measured to distinguish developmental phases. These included: total root and branch root number, average root and branch root length, number of short days between induction and anthesis, leaf shape, leaf length and width, leaf length : width ratio, leaf area, internode length and diameter, and phyllotaxy.

Materials and Methods

Six groups of poinsettia seed (cross between ‘Annette Hegg’ and ‘Eckespoint Lilo’) were sown 2 weeks apart on 29 May and 7 Aug. 1987 to obtain six age groups. The seeds were sown in Metro Mix 350 (W.R. Grace, Fogelsville, Pa.) in 23-cm2 cells and maintained under an intermittent mist cycle with bottom heat (24C) and natural long days in a greenhouse. Four weeks after each sowing, the seedlings were transplanted into 0.425-litre pots and transferred to another greenhouse location, where they continued under long-day conditions with 18C nights and 24C days.

Plants in all six age groups were then exposed to short-day (photoperiod) conditions beginning 24 Sept. 1987. Therefore, the time interval that the plants were exposed to vegetative long-day conditions before inductive short-day conditions ranged from 2 to 12 weeks, with 2-week intervals.

Rooting ability. Cuttings from each group were taken 24 Sept. and stuck in Metro Mix 350. After 3 weeks, the number of total roots and branched roots initiated to a length of 1 cm and the average length of roots and branched roots were recorded.

Flowering ability. Flowering dates were recorded for plants from each of the six groups when the first cyathium became visible.

Leaf characteristics. For each plant, the top four leaves that had reached at least 1 cm in length were observed for the following: 1) general shape of leaves, 2) leaf length, 3) width, 4) length : width ratio, and 5) leaf area (using portable area meter model LI 3000; LI-COR, Lincoln, Neb.). For purposes of analysis, leaf shape was converted into a 7-point rating scale as follows: 1 = elliptical, 2 = mixture of elliptical and ovate, 3 = ovate, 4 = mixture of ovate and partly lobed, 5 = mixture of ovate and lobed, 6 = lobed, and 7 = mixture of partly lobed and lobed. For each age group of poinsettias, an average heterophyll rating was obtained.
Fig. 1. Poinsettia growth characteristics over 2 to 12 weeks after establishment that identify developmental phases: (A) number of short days to flower, (B) total number of roots, (C) average root length, (D) total number of branched roots, (E) average length of branched roots, (F) heterophyll rating, (G) leaf length, (H) leaf width, (I) leaf length : width ratio, (J) leaf area, (K) internode length, (L) internode diameter, (M) percent of plants exhibiting (X), ½ (▲), or ¾ (■) phyllotaxy.

**Internodal characteristics.** Lengths and widths of the internodes of the top four leaves that were 1 cm long or longer were measured with a caliper on every plant.

**Phyllotaxy.** The phyllotaxy was determined by drawing a line from leaf to leaf, starting with the top leaf that was at least 1 cm long and ending with the leaf directly below it.

**Statistical analysis.** The experimental design was completely randomized with four replications and four plants per replication. The experiment was conducted twice, the first beginning 29 May 1987 and the second one 15 Aug. 1987. The means for each characteristic measured were plotted, with mean separation by Tukey HSD test P = 0.05. To further conceptualize the
Table 1 Factor loadings of poinsettia age groups for juvenile and mature developmental phases.

| Age group (weeks) | Factor loadings |        |        |
|-------------------|-----------------|--------|--------|
|                   | Juvenile        | Mature |        |
| 2                 | 0.92            | 0.40   |        |
| 4                 | 0.89            | 0.46   |        |
| 6                 | 0.85            | 0.52   |        |
| 8                 | 0.52            | 0.85   |        |
| 10                | 0.38            | 0.92   |        |
| 12                | 0.49            | 0.86   |        |

Principal components factor analysis with orthogonal rotation. The two factors represent 99% of the variance in the correlation matrix of six poinsettia age groups over all characteristics measured. 

Results

Flowering ability. The plot of the means for each age group (Fig. 1A) indicates that the older the plants were before induction, the shorter the period required for flowering. The sharpest reduction in the time interval between induction and anthesis occurred between 6 and 8 weeks from the time they were removed from the mist as established seedlings to the time they were exposed to short-day conditions.

Rooting ability. Measurements of total number of roots and branched roots and average root and branched root length (Figs. 1B–E and 2) indicated a general decline in rooting ability as the age of the plant from which the cuttings were taken increased. These measurements indicated that the decline was the steepest in plants that were between 6 and 8 weeks old.

Leaf characteristics. Leaf shape, expressed as heterophyllity rating, differed with age (Fig. 1F). Younger plants (2 and 4 weeks old) produced predominantly elliptical or ovate leaves, while older plants (6 through 12 weeks old) generated a higher percentage of lobed leaves.

Leaf length (Fig. 1G), width (Fig. 1H), length : width ratio (Fig. 1I), and area (Fig. 1J) all increased with plant age up to 6 to 8 weeks.

Inter-nodal characteristics. Internodal length increased substantially in plants older than 6 weeks (Fig. 1K), but internodal diameter increased up to 6 weeks and then remained nearly constant (Fig. 1L).

Phyllotaxy. Most seedlings of the 2-week group and some from the 4-week group had a 1/3 phyllotaxy. All the seedlings of the 6- and 8-week groups, some of the seedlings of the 4- and 12-week groups, and a few of the 2- and 10-week groups, had a 2/5 phyllotaxy. Some of the seedlings of the 10-week group and most of the 12-week group had a 3/8 phyllotaxy (Fig. 1M).

Discussion

Data for the individual characteristics and the pattern of factor loadings revealed two distinct developmental phases, juvenile and mature. The data also suggested that the expression of characteristics representative of the juvenile phase declined sharply between weeks 6 and 8 and that the expression of the mature phase advanced between weeks 6 and 8.

Means for leaf length, leaf length : width ratio, leaf area, and internode length and diameter support these conclusions. However, because these characteristics exhibited similar mean values in both the juvenile and mature developmental phases, they are more difficult to use in distinguishing the phases. Mean values for flowering ability, rooting ability, phyllotaxy, and heterophyllity were different in the two developmental phases, rendering them more useful in identifying developmental phases in poinsettia.

The plant characteristics associated with the juvenile phase included a relatively long period between induction and anthesis, rapid rooting of cuttings, a phyllotaxy of 1/3 to 2/5, and a predominance of elliptic to ovate-shaped leaves. Features generally associated with the maturity phase included a relatively short period of time between induction and anthesis, poor rooting of cuttings, a phyllotaxy of 2/5 to 3/8, and a predominance of lobed leaves.

With the establishment of juvenile and mature developmental phases in poinsettia and the tools to readily distinguish them, the relationship between stock plant and/or cutting developmental phase and splitting tendency can be investigated.

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