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FIELD PHENOLOGY OF RED GINGER, *ALPINIA PURPURATA*

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Additional index words. Growth, mathematical model, tropical cut flower.

Abstract. **The growth of red ginger, *Alpinia purpurata* (Vieill.) K. Schum., was measured weekly at two locations in Hawaii from time of stem emergence to harvest. One site, a commercial field, was studied in the summer and in the winter. The other site, on an experimental farm, was studied only in the summer. Parameters of growth were stem length and number of leaves. All studies showed the same growth patterns. A quadratic equation was the best model to describe weekly stem growth for all sites. Differences in growth were attributed to seasonal factors rather than locational ones.**

Red ginger, *Alpinia purpurata* (Vieill.) K. Schum., is a popular tropical landscape ornamental that has been grown in gardens in southern Florida (Burch et al., 1987). To develop red ginger as a cut flower crop for commercial production in Florida requires the use of greenhouses and other product demands (Broschat and Donselman, 1988). Fertilization may be needed for sandy soils (Criley, 1984). However, most domestic red gingers come from Hawaii where the annual value of sales was about $800 thousand in 1991 (HASS, 1992).

Red ginger is grown in Hawaii as a field crop. The plant stems, which arise from a rhizome system, may range in height from 1 to 5 m; the floral spike, composed of red bracts, is at the end of a leafy stem and may be as long as 30 cm (Neal, 1965; Criley, 1989). The inflorescence is produced year round if moisture, nutrition and temperature are adequate (Criley, 1989), and the crop is harvested as a cut flower before the inflorescence is about two-thirds open (Broschat and Donselman, 1988).

Information on the rate and pattern of growth would be useful to producers in anticipating time of harvest. Improvements in production techniques, such as fertilizer application and irrigation, can be easily demonstrated by comparisons with a simple mathematical growth model. The objectives of this study were to determine if such a model was feasible and, if so, was it independent of location, time of year and production practices.

Reference to brand name does not constitute endorsement by the U.S. Dept. Agr. Appreciation is extended to Carey Suefuji (Hilo, Hawaii) for the use of his ginger field as a study site, and to Arnold H. Hara, Victoria L. Tenbrink and Trent Y. Hata (Univ. of Hawaii at Manoa, Hilo, Hawaii) for their assistance and support.

Materials and Methods

Measurements of red ginger growth were taken at two sites on the Island of Hawaii. The first, "Papaikou", was a commercial field 6 km northwest of Hilo. Plants were grown in clumps of ca. 1 m in diameter and separated from each other by ca. 3.3 m of mulched-covered open space. Management practices included systematic irrigation, weed removal, field sanitation, and an active pest management program for insect control. The site was surveyed during the summer (starting 29 June 1989) and in the winter (starting 15 Feb. 1990). Data collection ceased with harvest.

The other site, "Waiakea", was on the University of Hawaii Experimental Farm, 8 km southeast of Hilo. Because this site was intended as a source of insect pests for examining potential postharvest disinfestation procedures for tropical cut flowers, no pest control was used. Plant clumps were separated by ca. 3.3 m of open area covered with mulch. Except during the initial planting, all watering was from rain. Compared to the previous site, this site was poorly maintained with little field sanitation. Plants were frequently infested with aphids and mealybugs. The site was surveyed starting 16 July 1989. Floral spikes were not harvested and data collection ended when all stems had open inflorescences.

A study plot was established at each site, composed of a 10 x 10 grid of plants with a surrounding border of plants. Within the plot, ten clumps were randomly selected and the youngest stem within each clump identified by a colored wire ring. Stem height, number of leaves and height of leaves, and plant condition were surveyed weekly until harvest.

Data were summarized and analyzed using SAS (SAS Institute, 1982). Regression models were determined by TableCurve (Jandel Scientific, 1991) and selected among those with the highest coefficient of determination (r^2). Pairwise comparisons of slopes were done using the formula

$$t = (b_1 - b_2) / S_{b1-b2} \quad \text{(Eq.1)}$$

where t is the Student's t value, b_1 and b_2 are the slopes, and s_{b1-b2} is the standard error of difference between the slopes (Zar, 1974).

Results and Discussion

At the Papaikou site, the time of harvest for the summer study was shorter (after 16 weeks) than for the winter study (after 20 weeks). For both sites, weekly stem length was a good indicator of plant growth. At Papaikou, stems from the winter study were longer with less variation than those from the summer study (Fig. 1a and 1b); maximum average stem length was ca. 100 cm. Stem growth at Waiakea was similar to the Papaikou summer study (Fig. 1c). A quadratic model among the nearly 300 models examined best described stem growth for all studies and was of the form

$$y = a + bx + cx^2 \quad \text{(Eq.)}$$

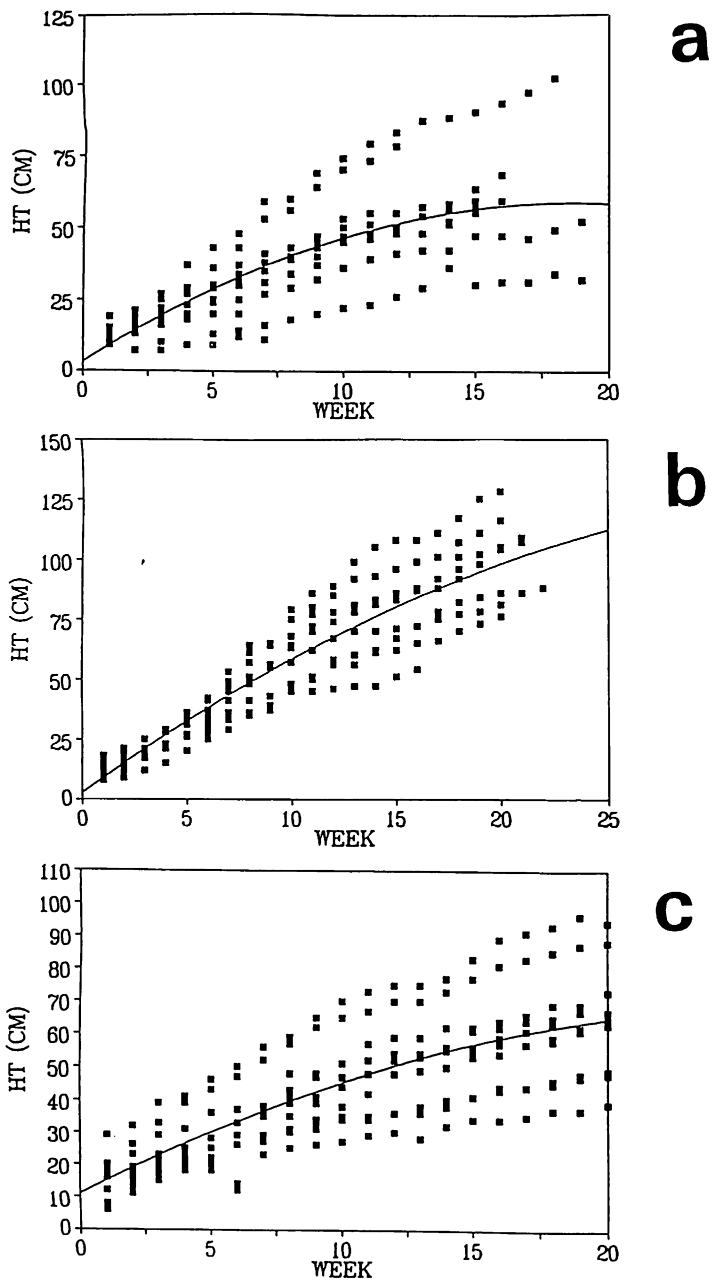

Fig. 1. Weekly stem length and descriptive growth model (Eq. 2) for field-grown Hawaiian red ginger; a, Papaikou—summer; b, Papaikou—winter; c, Waiakea—summer.

where y was stem length (in cm), x was time in weeks, and a, b, and c were coefficients (Fig. 1; Table 1). The growth model reflects only stem growth and does not infer total

Table 1. Calculated parameters and coefficients of determination by regression analysis for the descriptive model of stem growth from Hawaii field-grown red ginger, $y = a + cx^2$.

Site	Time	r^2	Coefficients a	b	c
Papaikou	summer	0.546	3.09	5.91	-0.16
Papaikou	winter	0.833	2.71	6.35	-0.08
Waiakea	summer	0.584	10.88	4.20	-0.07

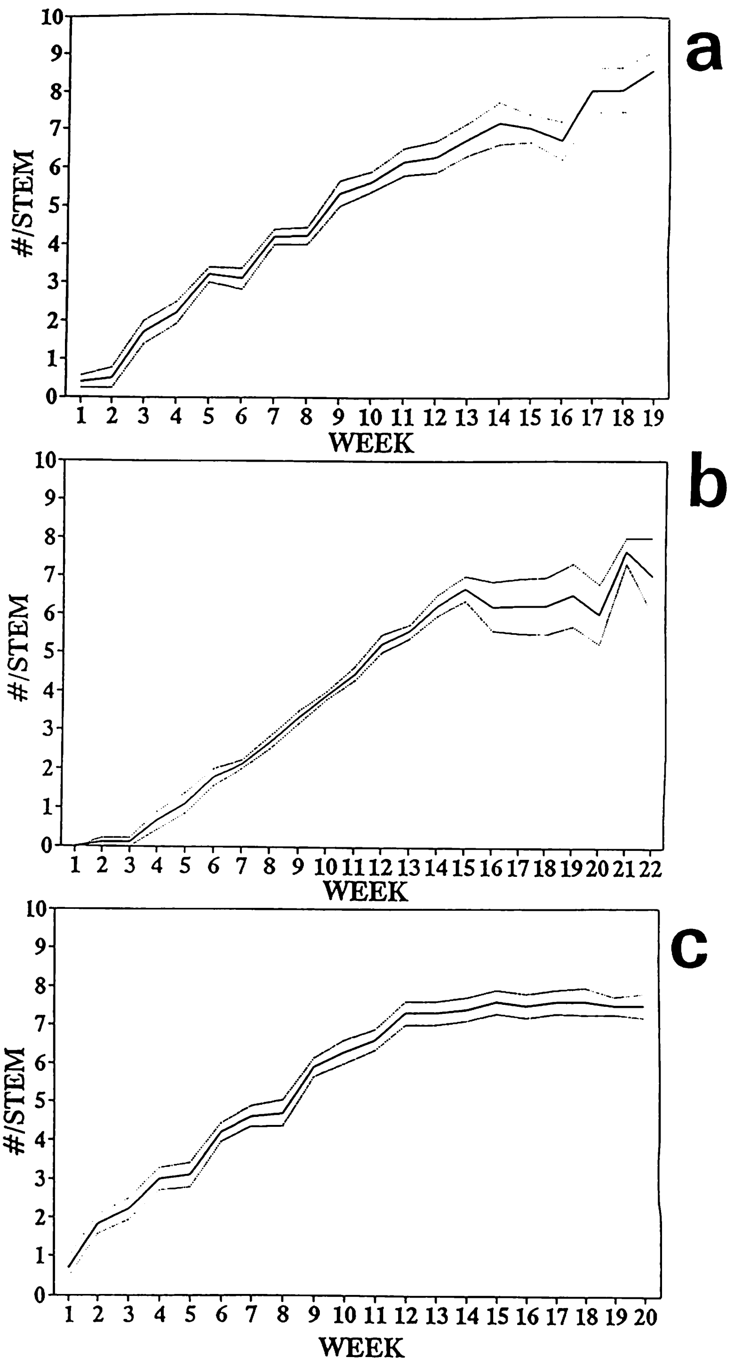

Fig. 2. Weekly number of leaves per stem ($\bar{x} \pm se$) for each field-grown Hawaiian red ginger (initial n = 10 for each survey); a, Papaikou—summer; b, Papaikou—winter; c, Waiakea—summer.

stem production or quality. A disadvantage because the model is a quadratic equation is that stem height will eventually curve down with time; however, this downward trend will occur long after the floral spikes are harvested. The only significant difference among the growth curves was between the Papaikou winter study and Waiakea (t = 2.31; $P < 0.05$). Stems may grow longer in other fields (Criley, 1984) and long stem inflorescences are commercially preferable in some situations.

Another approach to measuring growth was using the number of leaves on the stem (Fig. 2). Again, the summer study at Papaikou and the Waiakea study were similar. Generally, the stem had seven to eight leaves at time of harvest (after ca. 4 months of growth). In contrast, Criley (1984) reported a linear relationship between the number of leaf nodes and time; after 11 to 13 nodes, growth slows, the inflorescence appears, and the floral spikes are harvested ca. 5 months after stem emergence.

The above analyses suggest that plant growth follows a particular pattern. Seasonal, rather than locational, factors may be more important in determining growth rates, even when the plants are poorly maintained. Although temperature can limit growth (Broschat and Donselman, 1988), other factors must be involved to explain why stems grew longer during the winter than the summer at the same site. Perhaps cloud cover or light intensity was also important.

For commercial production in Florida, Broschat and Donselman (1988) recommended growing red ginger in greenhouses. Growth rates reported here for Hawaiian field grown ginger may differ from those produced in Florida or other sites in Hawaii. Additional data are required to determine if the growth model is applicable elsewhere. However, the growth model provides a standard for comparisons in developing a cut flower industry in Florida for red ginger. Quantifying growth may be an important tool for making management decisions.

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PREEMERGENT CONTROL OF *PHYLLANTHUS TENELLUS* AND *PHYLLANTHUS URINARIA*

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Abstract. **Two applications of 10 preemergent herbicides or herbicide combinations applied 10 weeks apart were compared for control of *Phyllanthus urinaria* and *P. tenellus* in a containerized medium of pine bark:Canadian sphagnum peat:sand medium (3:1:1, by vol.). After the treatments were applied and irrigated in, 25 seeds per species were applied to each weed-free 2.5-liter container. For each species, there were four replications per treatment and three pots per replication. Weed control was evaluated 5 and 10 weeks after each treatment; weeds were also harvested at 10 weeks. Oxadiazon (4.5 kg ai/ha) provided excellent control of both species for 10 weeks after one or two applications. Good to excellent control of both species was obtained with dithiopyr (2.2 kg ai/ha) and prodiamine (2.2 kg ai/ha). However, metolachlor (2.2 kg ai/ha) tank-mixed with prodiamine (2.2 kg ai/ha) caused a reduction in weed control. Isoxaben + oryzalin (0.9 + 3.6 kg ai/ha) and isoxaben + metolachlor (1.1 + 2.2 kg ai/ha) provided good control of both species 10 weeks after one application but only 5 weeks after the second application.**

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Introduction

Phyllanthus urinaria L. (chamberbitter, leafflower) and *Phyllanthus tenellus* Roxb. (long-stalked phyllanthus) are two warm season weeds that are becoming major problems in turf and ornamentals in Florida and other states in the southeastern U.S. (Elmore, 1990). Only a limited amount of research has been published with regard to their control. However, oxadiazon seems to be the active ingredient that consistently provides preemergent control of both species (Norcini and Aldrich, 1992; Stamps, 1991; Stamps and Poole, 1987; Wehtje et al., 1992). Other herbicides that provide preemergent control of one or both species are dithiopyr, isoxaben + oryzalin, oxyfluorfen + oryzalin, and oxyfluorfen + pendimethalin (Norcini and Al-