Techniques of cultivation in the Ornamental Zingiberaceae[1]

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Many different gingers are grown commercially for cut flowers, spices, dyes, and medicinal uses. A few also are grown for potted plants and for perfume essences. In Hawaii, a special style of lei is made using the blossoms of the fragrant white *Hedychium* ginger.

The popular cut flower ginger include *Alpinia, Zingiber, Tapeinochilus, Etlingera, Curcuma,* and some *Costus* and *Globba* species. In Hawaii, and elsewhere in the tropics, *Alpinia purpurata* is the most widely grown ginger for the cut flower trade.

The genus *Alpinia* is the largest one in the family Zingiberaceae with over 225 species distributed from India and China eastward into the Polynesian islands. Rhizomes of all species produce upright, unbranched leafy stems which terminate in an inflorescence cluster of varying attractiveness.

The chief commercial cut flower species is the red ginger, *Alpinia purpurata* Viell., which occurs in the Moluccas to New Caledonia and Yap and is now widely distributed across tropic and subtropic areas. The leafy stems range in height from 1 to 4 meters and the inflorescence to about 30 cm. Red bracts subtend inconspicuous, tubular white flowers. Although perfect, the flowers are probably self-incompatible as seed capsules are seldom found. As most of the commercial plantings probably arose from a limited original source, vegetatively propagated, little variation seems to exist. Pink-bracted and multiple-headed inflorescences have been selected (Table 1) (TAG, 1987). Seedlings of varying merits have been produced with some recent commercial selections achieving prominence in Hawaii (HIRANO, 1991).

PROPAGATION

Vegetative propagation is by division of the rhizomes or rooting of aerial offshoots produced in the axils of the inflorescence bracts. From rhizome divisions having 2 to 3 aerial stems, flowers can be harvested in year's time after re-establishment, but plantlets from the aerial offshoots require about 2 years to produce a sufficient plant mass to support marketable blooms. Some growers will cover the emerging offshoots in an inflorescence as in a simple layer to hasten rooting produce a larger plant. Treatment of the aerial offshoots with 500 ppm IBA or NAA improves speed and extent of rooting (CRILEY, 1988).

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TABLE 1. Descriptions of selections of *Alpinia purpurata* grown in Hawaii. Colors from Royal Horticultural Society Colour Chart.

Selection/ Cultivar	Bract color	Height	Notes
		m	
Red ginger	Dark red 53A to 60C	1-4	Common form with elongated inflorescence; aerial offshoots produced abundantly.
Eileen McDonald	Dark pink 54A to 54C	1-2.5	Elongated inflorescence; aerial offshoots produced abundantly. Bracts discolor easily.
Jungle King	Dark Red 53A to 60C	2-4	Rounded inflorescence; does not produce aerial offshoots; sturdier stems than common red.
Jungle Queen	Light pink 56D to 73D	2-4	Rounded inflorescence; does not produce aerial offshoots readily; fades in strong light; strong stems.
Tahitian	Dark red 53A to 60C	2-4	Tight multiple head, torch-shaped; produces aerial offshoots abundantly.
Kimi	Edge of 63B to 66D, blending to 65C-D in middle & base of bract	2-4	Somewhat rounded. Does not produce aerial offshoots. Lightest pink of the Ginoza series. Less bract tipburn than Eileen McDonald.
Kazu	Edge of 60B-C Inside 66C blending to white at base of bract	2-4	Somewhat rounded. Heavy stemmed. Throws aerial offshoots sparsely. Dark red edges with lighter mid-portions of the bracts.
Raspberry	Edges dark red 53A to 60A blending through 63A to 63D in midbract	2-4	Somewhat rounded. Darkest of the Ginoza series. Occasional aerial offshoot production.

Breeding work has been carried out in Hawaii (HIRANO, 1991) and Australia within *A. purpurata*. The common red ginger and the pink cultivar Eileen McDonald are both self-incompatible and do not cross with each other, but will cross with the 'Jungle King' and 'Jungle Queen' cultivars. Pollen is transferred onto a receptive stigma early in the day as the flower lasts but one day. From pollination, it takes 11 to 13 weeks to mature seeds. The fruit is red when ready to harvest.

Fresh seed of *Alpinia purpurata* germinate in about 4 to 12 weeks time when sown shallowly on a damp organic medium. When the resulting plants are fertilized heavily, some flowers will be produced in 2 to 3 years after seeding.

CULTURE

Medium

A well-drained medium with high fertility is recommended. Red gingers have also been grown in sandy soils in Florida and in volcanic cinders in Hawaii. In poorly drained soils, considerable chlorosis has been observed which was attributed to high manganese content in the soil. Chlorosis due to high pH or calcareous soils is a common problem in Hawaii landscape settings. The pH of the medium may range from 5.5 to 6.8 if fertilization practices supply needed microelements.

Spacing

In research conducted at the University of Hawaii, 3 planting densities were evaluated. Planting densities of 2.5, 4, and 10 plants/m^2 produced, respectively, 30.8, 22.4, and 9.6 marketable flowers/plant/year or 77,90, and 96 flowers/m^2/year in the third and fourth years after planting (CRILEY, 1984). Due to growth rate (Figure 1), which increased the plant diameter by about 10% per year once a mature size was reached, our recommended in-row spacing is 1.2 to 2 M. Commercial growers also thin out weak flower stalks, leaving 8 to 12 heavy stems/M of row.

Nutrition

Grower practice is a handful of fertilizer distributed around the plant 3 to 6 times a year using anything from a 1:1:1 to 3:1:5 (N:P:K) fertilizer. Quarterly applications of 1:1:1 analysis fertilizer to deliver rates of 0, 150, 300, and 600 kg N/ha/year produced no yield differences (all were about 1000 inflorescences per 100m^2 per year) on a fertile soil in Hawaii (CRILEY, 1984), but these levels were well bellow the 1420 to 5680 Kg N/ha/year rate found to increase saleable flowers by 59% in Florida (BROSCHAT & DONSELMAN, 1987). The marketable yield results in Florida increased from 36 to 61 flowers per square meter per year as N fertilization was increased from 142 to 568 gm N/m^2/yr.

Based on tissue sampling of field fertilizer trials in Hawaii (Table 2), suggestions are made for minimum elemental content in healthy green foliage of *Alpinia purpurata* (Table 2). No one fertilizer ratio was proven superior.

Irrigation

Recent irrigation experiments at the University of Hawaii evaluated yields and quality of inflorescences on plants irrigated at 0.33, 0.67, 1.0 and 1.67 times the amount of water loss indicated by evapotranspiration calculations for the preceding week. Both yield and quality improved with heavier irrigation (Table 3) (INOUYE, 1994). Under our conditions, the "rule of thumb" of 25 mm water at each weekly

Table 2. Representative elemental contents of red ginger foliage from plants supplied fertilizers of various analyses.

Element	Range (Dry weight basis)	Recommended minimum values
Nitrogen	1.97 - 2.46%	2.0%
Phosphorus	0.14 - 0.19%	0.16%
Potassium	1.41 - 1.92%	1.8%
Calcium	1.22 - 1.92%	1.8%
Magnesium	0.48 - 0.65%	0.4%
Manganese	362 - 1130 ppm	450 - 700 ppm
Iron	20 - 70 ppm	30 - 60 ppm
Copper	8 - 18 ppm	10 - 15 ppm
Zinc	40 - 118 ppm	40 - 90 ppm
Boron	14 - 24 ppm	15 - 25 ppm

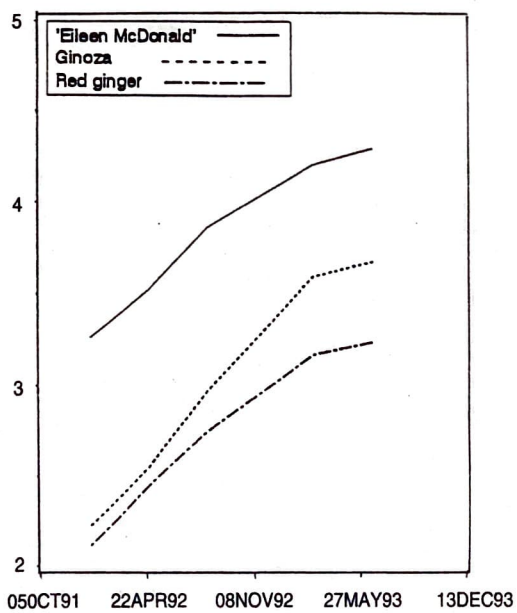

Figure 1. Increase in productive circumference of red ginger clumps during an 18 month period. Flower stalks are borne along the periphery of the clump, so this figure represents also potential yields during early years following establishment (from INOUYE, 1994).

irrigation was not quite sufficient for best quality although yields were adequate.

Light

Red ginger grows best under conditions of full sunlight but some yellowing of the foliage occurs in high or low temperature conditions. No bract burn is observed on red ginger, but the pink cultivars suffer from a tip burning disorder which seems diminished when the plants are grown with 30% shade. The flower yield (Table 4) and the rate of development of red ginger in last 5-6 weeks prior to harvest has been suggested to be dependent upon the solar integral received by the plant (Figure 2) (CRILEY, 1984). The pink cultivar, Eileen McDonald, develops brown bract tips under high light conditions and produces a better quality flower under light shade (@ 30%). The new Ginoza series ('Kazu, 'Kimi', and 'Raspberry') do not show this burn.

Temperature

Red ginger is tolerant of temperatures bellow 10ºC and should be grown in conditions of 16ºC or higher. Where minimum temperatures are above 21ºC, an emerging stalk will flower in 4.5 to 5 months (Figure 3) (CRILEY, 1984; INOUYE, 1994). Where temperatures are not limiting, flowering is year-round if moisture and nutrition are adequate.

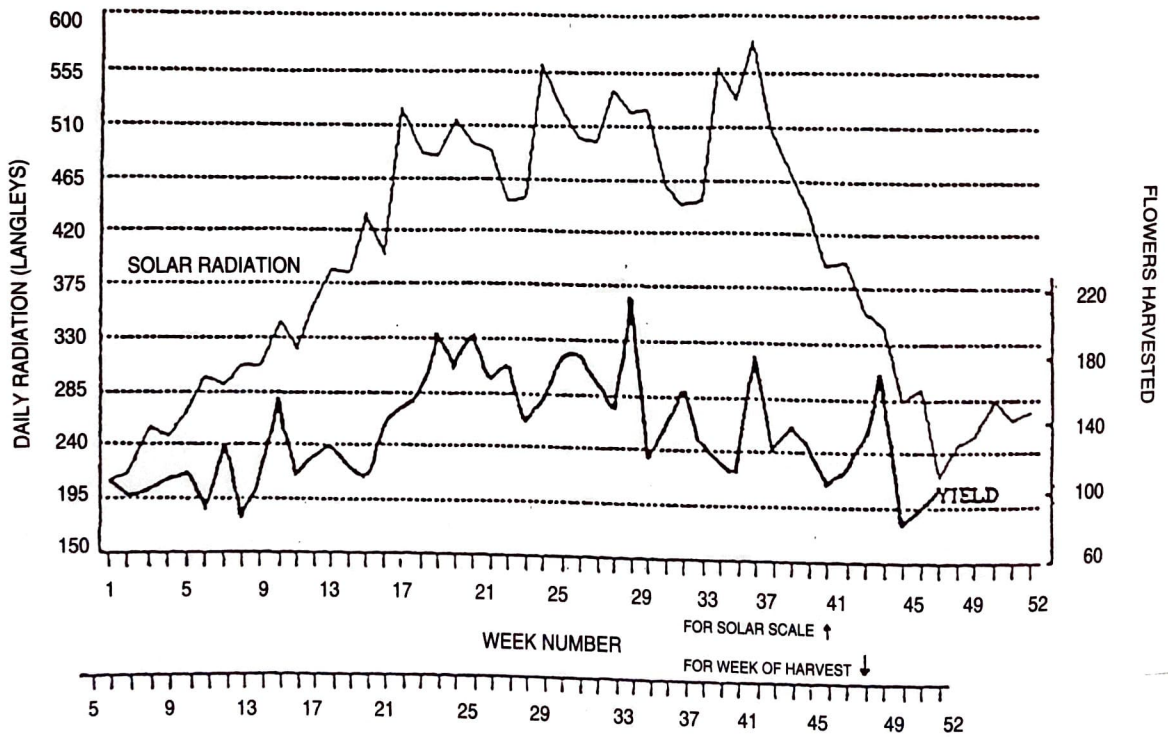

Figure 2. Correspondence of average weekly red ginger yields over 3 years lagged 5 to 6 weeks behind the average daily solar radiation curve for the same 3 years at Waimanalo, Hawaii. These data suggest that the final development of the inflorescence is strongly influenced by solar integral of the last 5 to 6 weeks before harvest (from CRILEY, 1984).

Table 3. Distribution of harvestable inflorescences of red and pink gingers by grade (inflorescence length) and by irrigation treatment for an 18 month period. (INOUYE, 1994).

Irrigation Treatment (Pan Factor)	Grade			Total
	Small 12.5 - 15 cm	Standard 15 - 20 cm	Fancy >20 cm	
0.33	466	880	288	1634
0.67	469	992	322	1783
1.00	490	1146	420	2056
1.67	438	1326	663	2477
TOTAL	1863	4344	1693	7900

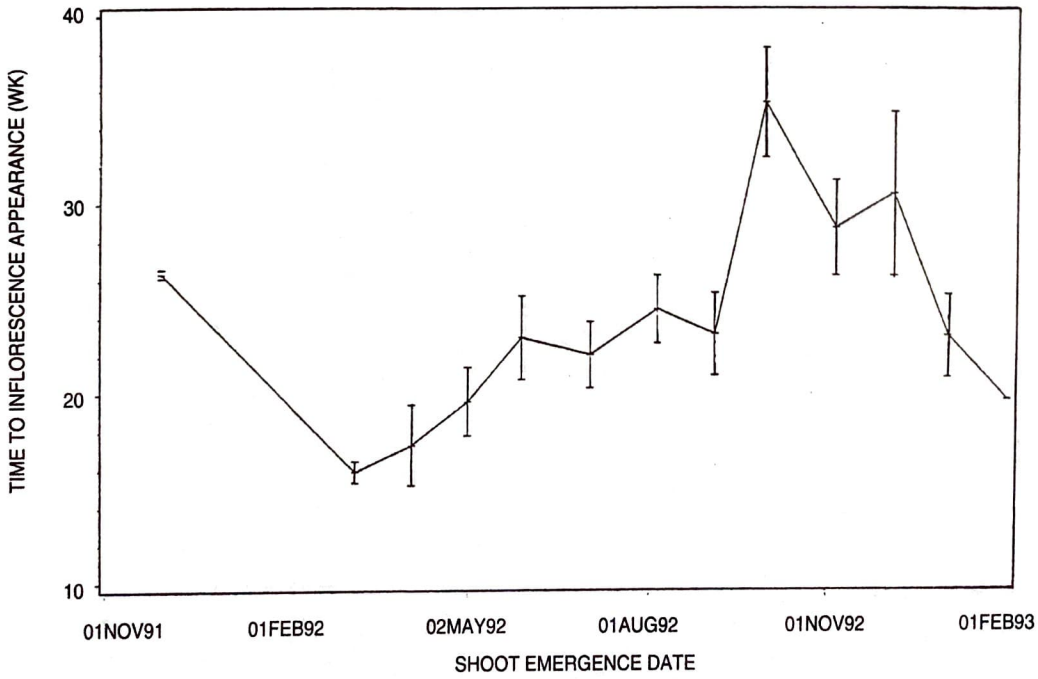

Figure 3. Mean length of time (+- Std Err) from shoot emergence to the appearance of the inflorescence for shoots of 3 ginger cultivars appearing at 13 tagging dates (from INOUYE, 1994). These data suggest a means for predicting harvest dates at a given location if the shoot emergence date is known.

PEST AND DISEASE MANAGEMENT

Insects

The long-lived nature of the inflorescence allows is to accumulate many types of insects which must be eliminated before it can be marketed. Chief among the undesirables are aphids, ants, mealybugs, and scales (HATA et al., 1992b). Cardamom thrips damage has also been reported (TSUDA & HARA, 1990). A preventive spray program is necessary to reduce insect populations and the damage they cause. Foliar sprays of chlorpyrifos have been more effective than barrier treatments infestations in the field (HATA et al., 1992a, 1992b), but post-harvest treatments in reducing are still necessary to achieve the degree of kill required by plant quarantine inspectors. Hawaii growers often soak the inflorescences in a solution of malathion or diazinon or a high sudsing detergent to kill and remove insects; this is followed by a fresh water rinse. More recently a combination of an insecticidal soap plus fluvalinate has proven very satisfactory as a postharvest dip (HATA et al., 1992b; TENBRINK et al., 1991).

Diseases

Although *Pythium* root rots develop in poorly drained soils, and nematodes have been isolated from red ginger root systems, these have not been major production problems in Hawaii. Since most of the foliage is removed from the stem before shipping, the few leafspot disorders cause little loss of product.

Weeds

The dense canopy shades out most weeds, but grassy weeds and vining weeds can still be problems. Growers of ornamental plants in Hawaii often use the pre-emergence herbicides oxydiazon

Table 4. Average weekly yields and development rates of Red Ginger over three years during periods of low, increasing, high, and decreasing solar radiation. (Adapted from CRILEY, 1984, and INOUYE, 1994)

Season (No. Wk)	Total daily solar radiation MJ . M^2	Flowers per square meter per week	Weeks from shoot emergence to harvest
Dec-Mar (17)	< 10	1.6	32-22
Apr-May (9)	10 -> 20	1.7	20 - 22
Jun-Aug (13)	> 20	2.6	28-30
Sep-Nov (13)	20 -> 10	2.0	30 - 40

(Ronstar), oryzalin (Surflan), oxyfluorfen (Goal) or a combination of the latter two (Rout) for weed control.

POSTHARVEST HANDLING

Stems are usually cut at ground level when the spike is about two-thirds to three-fourths open, and the foliage stripped to leave one to three leaves just bellow the inflorescence. The dense bracts accommodate many types of insects and require carefully cleaning by hand to dislodge and eliminate them. Plant quarantine inspectors give careful attention to these flowers and the presence of live scale , mealybugs, aphids, or ants is a basis for rejecting shipments. A hot water dip (47º C for 5 minutes) eliminated aphids in red ginger (HANSEN et al., 1991c) while an exposure to 1 hour of vapor heat (water-saturated air heated to 46.6º C) killed most insects and left the ginger inflorescences undamaged (HANSEN et al., 1992). Still, the best recommendation calls for reducing field populations of insects with preharvest insecticide applications followed by postharvest insecticidal dips and a final visual inspection.

The red ginger flowers should be stored at 12ºC or above to reduce damage to the bracts (BROSCHAT & DONSELMAN, 1988). Stems are placed upright in buckets of water because they develop a curvature in the tip if stored horizontally.

The useful vaselife of red gingers benefited from the use of floral preservatives containing 2% sucrose and 200 ppm 8-hydroxyquinoline citrate, achieving 15 days versus 10 days for deionized water only (BROSCHAT & DONSELMAN, 1988). Small caliper stems have a short vaselife ~ five days. Inflorescence longevity was also improved by benzyladenine or anti-transpirant dips plus holding in a 2% sucrose solution (WHITTAKER et al., 1992). An acidifying agent, 5µM citric acid trebled vaselife, perhaps by antibacterial action (TIJA, 1988).

OTHER GINGERS

Other gingers grown for cut flowers in Hawaii include *Etlingera* (the torch or tulip gingers), *Zingiber* (the shampoo gingers), *Tapeinochilos ananassae* (wax ginger), *Curcuma* and a few *Costus*. *Hedychium* is grown for its fragrant flowers for the landscape, for hair adornment, and for leis. Recently, *Globba winitii* has joined the ranks as one grower has found it has an extraordinary vaselife. For none of these have details of culture been carefully worked out.

Some specific issues requiring attention include the ease of bract bruising and short vaselife for *Etlingera elatior* and *E. hemisphaerica*. They are more easily packed when picked before the bracts have reflexed. The *Zingiber spectabile* and *Z. zerumbet* gingers bloom seasonally and have copious fluid content which makes shipping awkward. The large heads of *Tapeinochilos* are heavy, and the bracts bruise easily; its vaselife is not as long as expected for such a large flower. Gingers of the genus *Curcuma* go through a dormancy period which is not well-understood. This makes timing of forcing a problem (Anon., 1993), but in the field, they happily flower on their own schedule. This group is a good candidate for research. The cut flower vaselife is not long for some species and bract bruising also diminishes inflorescence quality. *Globba* also undergoes a dormancy. New color

forms await introduction and new species await discovery and description. In the *Costus* group, individual flowers last but a day, then wither - a trait not favored by the florist - but the colorful bracts remain in good condition for days, making some species suitable for commercial culture.

OTHER RESEARCH

Bits and pieces of research on the edible and medicinal gingers have been conducted in India, China, and elsewhere in southeast Asia. Many deal with micropropagation (BALACHANDRAN et al., 1990; SUGAYA, 1991; YASUDA et al., 1988), rhizome dormancy (ABAD FAROOQI et al., 1987), and nutrition (LIU et al., 1974; PHILIP, 1980). These offer some starting points for worthwhile research.

SUMMARY

A somewhat generalized production program for gingers might be adapted from the practices employed for the edible ginger, *Z. officinale* Rosc. (NISHINA et al., 1992). Deep, well-drained soils, high in organic matter with a pH of 5.5 to 6.5 are prepared to receive the rhizome "seed" pieces by plowing to a depth of 40-60 cm, incorporating limestone to adjust the soil pH and supply calcium. Nematicides or fumigants are used to eliminate nematodes. Field sanitation is important, and clean fields should be constructed to prevent contamination by run-of from outside soils. While the edible ginger is grown on raised beds to facilitate harvest of the rhizomes, this would not be necessary for cut flower gingers. Where the seed pieces of edible ginger are treated in hot water (50°C for 10 minutes) to kill nematodes and fungicides are dusted upon the rhizomes to reducing diseases, such practices are not often employed with the ornamental gingers, although they most certainly would improve the initial quality of the stand.

Fertilizer is usually incorporated into the soil prior to planting the seed pieces. The favored ratios are 1:1:1 and 1:3:1, which, for fertilizers of 14-14-14 or 10-30-10 analysis, are applied at 336 and 560 kg/ha, respectively. Phosphorus may additionally be supplied as 0-47-0 analysis treble superphosphate at 1120 kg/ha. Calcium is supplied as either calcium carbonate or dolomite at 1120 to 2240 kg/ha. Fertilization after planting is more frequent for edible ginger than for the cut flower types. A Hawaii study suggested that fertilizer application at 2 month intervals was superior to 3 month intervals (HASHIMOTO, 1987). Recent Hawaii data suggest that N levels of 336 kg/ha give the best growth and yield for the red gingers (MERSINO, 1994). However, rainfall and soil type modify nitrogen retention, and rates will vary by site.

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