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Domesticating *Haemodorum coccineum*©

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Summer visitors to tropical Queensland or the Northern Territory can hardly fail to notice the vividly coloured, lily-like flowers of *Haemodorum coccineum* (scarlet bloodroot) and it is surprising that they have not already been brought into cultivation, particularly as a cut flower crop. However, the domestication of a plant species is not always as easy and straightforward as one would hope. Despite being very easy to propagate, growth of *H. coccineum* appears to require soil temperatures in excess of 22°C at rhizome depth. This unique dormancy mechanism may limit production to tropical environments.

INTRODUCTION

The Haemodoraceae are a family of monocotyledonous plants comprising 14 genera and about 100 species worldwide. They resemble the Iridaceae and have similar characters including ensiform leaves and bulbous, rhizomatous, or stoloniferous roots. Of the seven Australian genera of Haemodoraceae only *Haemodorum* extends beyond Western Australia (Macfarlane et al, 1987). The name *Haemodorum* refers to the red colouring of the rootstock and sometimes other plant parts, hence the common name 'bloodroots'. About 18 species have ornamental potential, and several of these could be used for cut flowers. This paper is concerned with the evaluation of *H. coccineum*, a plant species native to northern Australia, and demonstrates the value of field studies, as well as greenhouse and controlled environment studies, when attempting to bring a species into cultivation for the first time.

FIELD OBSERVATIONS OF NATURAL POPULATIONS

The climate in which *H. coccineum* thrives naturally is generally described as tropical with summer rainfall. The summers are characterised by heavy periodic rains which can be very heavy in coastal and highland regions, with very high humidity especially near the coast. Winters are mild and generally dry. Variability in total rainfall from one year to the next means that annual averages are not helpful, but the species grows in an area where the median rainfall is above 600 mm per annum. Average daily global radiation during the growing season is between 500 and 650 $mW \cdot cm^{-2}$.

In herbarium records sand, sandy loams, gravelly loams, lithosols, and skeletal soils are the terms mainly used to describe the substrate, with occasional references to other soil types. A simple particle size analysis was done for ten sites. The average distribution by weight was gravel 38%, sand 59%, and silt and clay 3% (U.S.D.A. particle size classes). The small silt/clay fraction allows some of these soils to bake quite hard during the dry season. Permeability was judged to be good for all soils and they were all free draining. Almost all plants were found on gentle to steep slopes or, in flatter topography, in slightly more elevated positions. In hilly country the soils are often quite thin. Rhizome depth varies from about 5 to 30 cm (commonly 10 to 20 cm). Measurements of soil moisture content were made during the dry season at several locations. This ranged from 4% to 21%. In July soil temperatures at rhizome depth ranged from 21 to 25°C depending on aspect and ground cover. In December, the range was 29 to 31°C.

Soil chemical analyses at a number of sites showed that the soils are all very acidic (mean pH 4.5) and are low in organic content (carbon content 0.5% to 1.0%). Typically they have low salinity, low cation exchange capacity, and low levels of all macronutrients. Zinc and copper are low, iron is generally adequate, and manganese is very variable. Aluminium levels are higher than many species would tolerate. The calcium to magnesium ratio is also uniformly low which would limit growth of many species. Field observations, herbarium records, and other published sources indicate that the main season for flowering is between December and March, approximately coinciding with the wet season. However, sporadic flowering has also been observed in any month in north Queensland (NQ) even when soil moisture levels are low. For example, flowering was observed on a north facing, recently disturbed, site in NQ in June with soil moisture of only 3.7%. Based on these observations it was clear that seasonal fluctuations of soil water content were not the primary factor in promoting flowering. Some herbarium reports also note flowering after fire.

The main period for growth of these species is similar to the pattern shown for flowering. During the dry season the aerial parts of the plant generally wither but the rhizome persists. Again, it appears that the onset of the rain season does not break dormancy, as growing plants can be found in the dry season. Excavating the rhizome in November or December, before the wet season starts and when soil moisture content is still low (actual measurements 4.2% to 9.9%), often reveals new fan buds sprouting.

LABORATORY AND PHYTOTRON STUDIES

Propagation. The seed is black, discoid, about 5 mm × 4 mm, and has a mean weight per seed of 38 mg (±2 mg). The seed coat contains a natural dye that is easily leached

out with water. Removal of the dye improved germination from 45% to 100% with freshly collected seed. Similar germination rates were obtained for seed up to 3 years old. There was no evidence of dormancy, and no apparent loss of viability during this period. This species is rhizomatous and its natural habit is for this to divide into separate plants after flowering. If plants are divided by separating rhizomes in the necrotic zone beneath a fan that has flowered then the individual parts generally survive. Dividing living rhizomes (i.e., cutting through the orange-red tissues) is possible but less successful.

Growth and Flowering in Pot Culture. Plants were grown in a potting medium containing perlite, vermiculite, sand, and peat (2 : 2 : 2 : 1, by volume). This mixture gave satisfactory growth for a period of 4 years. Nutrient was added as either low-phosphorus formulation slow-release fertiliser (purple 'Nutricote'), or as Hoaglands No.2 nutrient solution (Hewitt, 1966). Other details of phytotron controls are given in Morse and Evans (1966). The phytotron is located in Canberra (35°18'S)

Plants grown at 26/18°C (day/night, mean 22°C) and 16-h or 10-h photoperiod (extension provided by 60-W incandescent lamps suspended 1 m above the plants) followed similar seasonal growth and flowering patterns as had been observed in the field. The only uncontrolled variables were solar radiation and humidity. These plants never became dormant as the above ground organs did not completely die back. However, from March to August there was almost no growth. Leaf production accelerated in late November, with maximum production between December and March. Fan numbers showed a similar pattern to leaf production, as did the production of flowering stems. There was no difference in inflorescence production between photoperiods.

Dormancy. Under greenhouse and phytotron conditions the aerial parts of the plants did not die back in the winter season (unless the whole plant died). If water was withheld for long periods of time the whole plant died and the rhizome appears not to be very resistant to desiccation. Despite being held at constant conditions in the phytotron (with the exception of solar radiation) the seasonal pattern of flowering was maintained, with sporadic flowering in the winter months and a flower flush starting in December each year. Growth also slowed considerably in winter. Some plants survived and flowered seasonally for 4 years without dormancy.

FIELD TRIALS

Trial crops were planted in two localities, one within the species natural range (Mareeba, Lat. 17° 00'S) and one in a subtropical environment (Gatton, Lat. 27°55' S). At the Gatton site the mean monthly maxima are very similar to some places within the natural range of the species, but the minima are a few degrees colder in winter. Annual rainfall also has a pronounced summer maximum, but winter rainfall is greater than in the tropics. The soil temperature at a depth of 20 cm is significantly cooler with more than 10 months below 25°C compared with just 5 months for Mareeba. The soil was a sandy loam. The particle size distribution was 95% sand, 4% silt and clay, and 1% gravel, and the carbon content is low (0.9%). Fertility was greater than in natural soils, with nitrogen, phosphorous, calcium, magnesium, and zinc being at higher levels. Planting was done in autumn. By late spring most of the plants were still alive but were not actively growing. A small number of flowers occurred

during the summer but not in a single flush. Plants that flowered died soon after as they were not producing new fans. None of the plants survived past the second summer season.

Although *H. coccineum* grows naturally in north Queensland some difficulties were experienced in field trials. Soil temperature at rhizome depth was recorded. Growth stopped in mid-April and aerial parts started dying back in early May. This appears to coincide with a fall in soil temperature at a depth of 20 cm to the low 20s. At another location plants were actively growing at 25°C at rhizome depth in August/September. This was a weed-free, mounded bed with exposed brown soil that may account for the relatively warm temperature of the soil. At one of the natural population sites flowering specimens were observed on disturbed ground on a north-facing slope in July. The soil temperature at rhizome depth was measured at 24°C. Nearby soils on flat areas, where the plants were dormant, were 3°C lower.

DISCUSSION

Tall, sturdy, visually attractive flower stems, easy propagation, and adequate flower life suggest this species has cut flower potential. Despite the ease of germination long-term establishment of plants proved to be very difficult except in field plantings in NQ. Initially it was suspected that the lack of suitable mycorrhizae was the cause of mortality. However, examination of roots collected in the field revealed that although some were heavily infected with vesicular arbuscular mycorrhizae others were not infected at all. Growth of seedlings in pots containing natural soil did not improve seedling survival.

Flower initiation is probably controlled by photosynthetic activity rather than by photoperiod or temperature as it can occur at any time of the year if conditions for growth are permissive. It is probable that flowering only occurs after the rhizome has reached a certain size. For example, Motum and Goodwin (1987) showed that in *Anigozanthos flavidus* the rhizome needed to be at least 175 g fresh weight before flowering could be initiated. *Anigozanthos manglesii* required a minimum weight of 75 g and *A. viridis* 25 g. The mean rhizome size for 15 flowering plants of *H. coccineum* was 22.4±3.1 cm^3, with a fresh weight of 22.7±3.1 g.

Vegetative growth can only be partly controlled by light as for part of the year the plant may be entirely underground. Dormancy and initiation of vegetative growth must therefore be by some other factor. Also it appears that if conditions are favourable this species does not require a dormant period to maintain long-term growth and flowering.

At Gatton, although summer conditions and soil structure and chemistry are very similar to those of northern Queensland plants did not survive. The most likely explanation is that the plants could not tolerate winter conditions. Possibly the problem was related to low soil temperature and/or winter rainfall combined with low soil temperatures. Other evidence from field observations in NQ and phytotron experiments (not reported here) suggests that dormancy in the crop is probably controlled by soil temperature. This needs further investigation if the hypothesis is correct this would be an important new control mechanism for dormancy as no one has recorded control at such high temperature either for geophytes or other classes of plants. This mechanism would also help to explain the natural distribution of this species and the observations that it thrives in bare ground and after fire (due to the

albedo change raising the soil temperature). It would also have some implications for crop management. Heavy mulching or poor weed control could reduce crop growth by reducing soil temperature. It will also severely limit the potential range of the crop. It is likely that it will only be possible to grow it in tropical climates, and local conditions such as aspect and ground cover, will need to be favourable as well.

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