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Basal heat improves adventitious root quality in Plumeria (*Plumeria rubra* L.) stem cuttings of different sizes

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Abstract

Root development of hardwood cuttings of *Plumeria rubra* was investigated in relation to basal heat and the size of cuttings. Terminal cuttings of a clone grown in Sicily were trimmed to various lengths, ranging from 10 to 26 cm. To verify the cutting rooting response to basal heat, half of the cuttings were placed on a basal heated bench (28±3 °C, constant temperature) while the remaining were placed on an unheated bench (16-18 °C during the night and 20-22 °C during the day). Percent rooting and cutting survival were not affected by basal heat and cutting length. However, basal heat positively affected number of roots, length of longest root and bud growth. Increases in the length of the cutting resulted in a parallel increase in adventitious root formation. Medium (16-20 cm) and long (22-26 cm) length cuttings exposed to basal heat exhibited the best development in terms of number of roots, root length and bud growth. We suggest that in the Mediterranean region the use of basal heat and of medium/long size cuttings may be beneficial to propagators wishing to produce *P. rubra* rooted cuttings with well-developed root system.

Key words: *Plumeria rubra*, propagation, adventitious roots, bottom heat, cutting size, frangipani.

Introduction

The genus *Plumeria* (Apocinaceae) is represented by seven species and several subspecies (Woodson, 1938) of trees and shrubs native to Central and South America. *Plumeria rubra*, also known as frangipani, is widely grown in tropical and subtropical areas of the world (Criley, 2009) mainly for landscape plantations. It is also specifically cultivated in Hawaii for the production of the worldwide known floral necklaces. Cultivated as an attractive ornamental tree in private and public gardens or in containers in balconies and terraces, the species thrives in the coastal areas of the Mediterranean island of Sicily, particularly in the mild coastal climate of Palermo, the island capital, where it is considered one of the official symbols of the city and appreciated since its arrival there in the early 1800's (Carapezza *et al*., 2005). *Plumeria* popularity has increased in recent years and various clones and hybrids of *P. rubra* are cultivated in Sicily both by amateurs and commercial nurseries; the typical form found in Palermo is characterized by a white corolla with a yellow centre. *Plumeria* propagation is usually done by terminal cutting in late spring when soil and air temperature favor rooting (Eggenberger and Eggenberger, 2000).

Cuttings are generally taken from mature wood and range in size from 7 to 30 cm (Bryant, 2003; Toogood, 1999). Although vegetative propagation by terminal stem cutting is successfully applied to *Plumeria* (Criley, 2009; Eggenberger and Eggenberger, 2000), rooting can vary depending on the cultivars, branch maturity, and rooting techniques (Little, 2006). According to Criley (2009), bottom heat (28-30 °C) generally hastens *Plumeria* adventitious root formation. However, to our knowledge, there are not specific studies concerning the beneficial effects of basal heating to root formation in *Plumeria* cuttings. Although the effects of factors such as cutting length and node number on adventitious root formation in woody species has been well documented (Beyl *et al*., 1995; Smalley and Dirr, 1987; Dirr and Heuser, 2006; Henry *et al*., 1992; Hinesley *et al*., 1994), no research on the influence of the morphological characteristics of the cuttings on *Plumeria* rooting has been reported. The aim of our study was to examine rooting of stem cuttings in relation to basal heat and cutting length in a *P. rubra* clone grown in Sicily.

Materials and methods

Terminal 30-cm-long hardwood stem cuttings were harvested during the first week of April 2011 from mature *P. rubra* trees grown in a private garden at Palermo (longitude 13° 19' E, latitude 38° 9' N) in the Northern coast of Siciliy (Italy). All the trees were of cutting origin and from a single clone. Stem cuttings were collected from the previous year's growth cycle in the middle of the crown of each of five parent trees. Prior to planting, the bases of cuttings were trimmed to three sizes: short (10-14 cm), medium (16-20 cm) or long (22-26 cm) length. Node number and average diameter of the cuttings ranged from 12.3 to 22.8 nodes and from 1.6 to 1.8 cm, respectively. Cuttings were stored for 2 weeks at room temperature in a shaded area. Propagation was performed in the first week of May in an unheated greenhouse covered with clear polyethylene and external 50% shadecloth. Cuttings were inserted to a 4-cm depth in benches containing a peat-perlite mixture 1 : 1 (v/v). Air temperature in the greenhouse was 18-22 °C during the day and 14-16 °C during the night. To verify the cutting rooting response to basal heat, half of the cuttings of each size group were placed on a bottom heated bench while the remaining were placed on an unheated bench. Basal heat was provided at constant temperature of 28 ± 3 °C. Rooting medium temperatures in the unheated bench were 16-18 °C during the night and 20-22 °C during the day. Intermittent mist operated daily 30 sec every 2 hours from 8:30 AM to 6:00 PM. Benches were covered with clear plastic to maintain high relative humidity. Ventilation of the cuttings was increased with time by increasing size of the holes made in the plastic. The design was a randomized complete block with four replications, six treatments [three cutting lengths x two rooting medium temperatures (heated bench vs unheated bench)] and ten cuttings per replication. After 4 and 7 weeks, cuttings were evaluated for percent rooting, percent survival, number of roots, length of the six longest roots, bud growth. Percentage data were subjected to arcsin transformation before ANOVA analysis. Mean separation was performed by Fisher's protected least-significant-difference test ($P \leq 0.01$) (Petersen, 1985). Single plants were transferred to plastic pots (diameter 16 cm) containing the same growing mix and kept for five weeks in a lath house covered with 70% shadecloth. Acclimatized plants were thereafter transplanted in the open field and are under evaluation for their ornamental performances.

Results and discussion

Percent rooting ranged from 97 to 99.5% and was not affected by basal heat or cutting length (Fig. 1). According to Bryant (2003), rooting in *Plumeria* can range from 50 to 75%, whereas Hata *et al.* (1994) in a study performed in Hawaii obtained 76% rooting in *Plumeria* hybrid "Donald Angus" by rooting tip cuttings in a greenhouse bench. In our study, *P. rubra* cuttings rooted at a rate substantially higher than that reported by these authors, even in the absence of basal heat. Our positive response could be related to diverse genotypes studied.

No significant effect of basal heat and cutting size was found on cutting survival which ranged from 97% to 98% (Fig. 1). Every surviving cutting produced roots and leaves; roots were evenly distributed at the cut basal portion of the cutting.

Regardless of cutting length, number of roots per cutting was significantly affected by basal heat (Fig. 2). Four weeks after cutting insertion in the rooting medium, roots formed at 28 ± 3 °C were more than 3 times superior in terms of root number to roots formed in the unheated bench (Fig. 3). After seven weeks, cuttings exposed to constant temperature of 28 ± 3 °C averaged 33 roots, compared to 18 roots for cuttings placed in the unheated bench. Basal heat has been often demonstrated beneficial for rooting of stem cuttings in several species (Loach, 1988; Blanchard *et al*., 2006; Greer, 2006; Iapichino and Airò, 2008; Iapichino and Bertolino, 2009). Rooting medium temperatures of 18-25 °C are considered optimal for most cool-season species, whereas higher temperatures (26-30 °C) are required for those from warm climates (Kester, 1970; Dykeman, 1976); on the other hand, sub-optimal temperatures are known to inhibit or limit adventitious root formation because the cuttings will not metabolize at a sufficiently rapid rate for optimum rooting (Preece, 1993). In this respect, *P. rubra* rooting requirement may be considered similar to that of other plants indigenous to tropical and subtropical regions. For example, *Ficus benjamina*, *Codiaeum variegatum* and *Aglaonema* 'Silver Queen' cuttings exposed to bottom heat (26-30 °C) produced more lateral and longer roots than those grown in unheated benches (Chen and Stamps, 2006). Hata *et al.* (1994) with *Plumeria* hybrid "Donald Angus" reported an average of 9 roots per cutting in an experiment performed under greenhouse conditions in an unheated bench. Based on our results obtained in the heated bench, we speculate that by maintaining the temperature in the rooting zone higher than that of ambient air it is possible to increase the number of roots per cutting in several *P. rubra* cultivars.

Root number also varied by cutting length, averaging 29 roots in long cuttings (22-26 cm), 24% higher than in short cuttings (10-16 cm) (Fig. 2). Medium size cuttings (16-20 cm long) averaged 26 roots. Long cuttings of tropical plants are expected to produce more roots because of the amount of reserve nutrients in the stem (Criley, 2008). There was no discernible relationship between basal heating and cutting length in terms of root number.

Root length was affected by the temperature of the rooting medium averaging 10.7 cm at 28 ± 3 °C and 7.7 cm in the unheated bench (Fig. 4). The main effect for cutting length was significant, but there was no significant interaction between basal heat and cutting length. Average length of the six longest roots was 11 cm for the long cuttings and 8.6 and 7.8 cm for medium length and short cuttings, respectively.

Bud growth was unaffected by cutting length, but significantly higher in cuttings exposed to basal heat (Fig. 4). Propagated plants grew vigorously, were morphologically normal and began

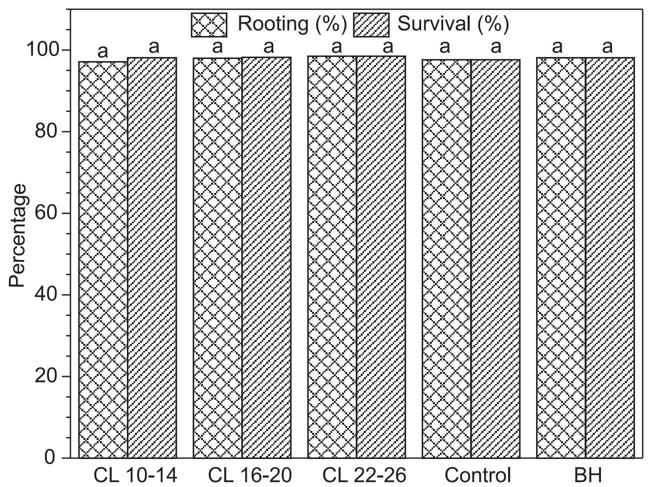

Fig. 1. Influence of cutting length (CL) and basal heat (BH) on *P. rubra* cutting survival and rooting. Bars with same letters are not significant by Fisher's protected least significant difference test ($P<0.01$).

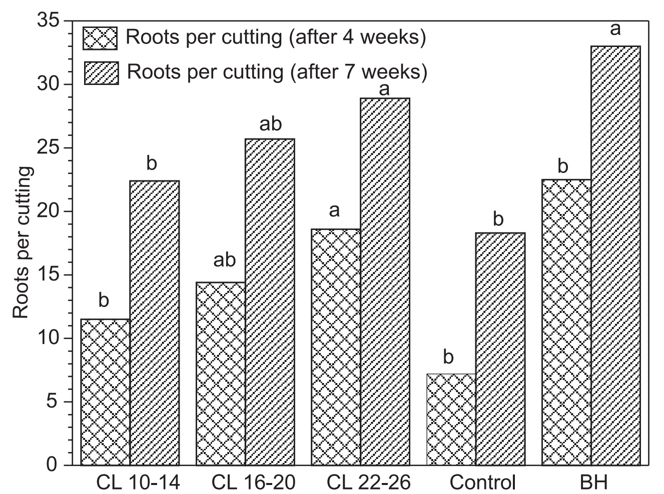

Fig. 2. Influence of cutting length (CL) and basal heat (BH) on *P. rubra* number of roots per cutting after four and seven weeks from planting. Bars with different letters are significant by Fisher's protected least significant difference test ($P<0.01$).

Fig. 3. *P. rubra* rooted cuttings (22 cm long) in the presence (left) and in absence (right) of basal heat.

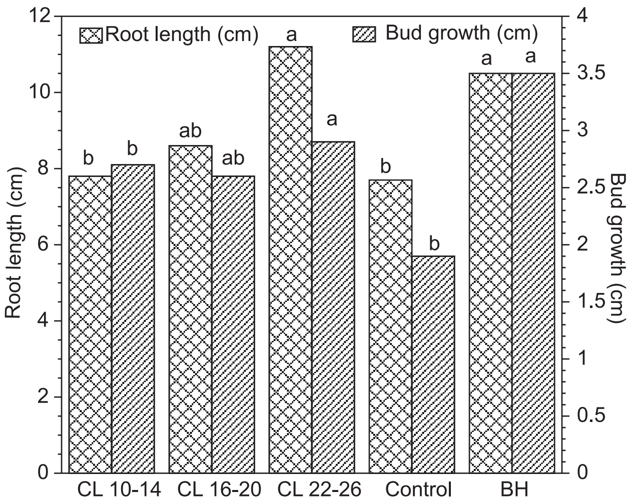

Fig. 4. Influence of cutting length (CL) and basal heat (BH) on *P. rubra* root length per cutting and cutting bud growth. Bars with different letters are significant by Fisher's protected least significant difference test ($P<0.01$).

to flower during summer 2013. The best treatments of the rooting experiment were repeated in the successive April 2012 with similar result.

In this report we demonstrate that the typical *P. rubra* clone found in Sicily has high rooting ability; basal heat significantly increased root number, root length, and bud growth compared to cuttings placed in the unheated bench, but not rooting percentage. In general, the longer the cuttings the better the response was in respect to number of roots formed and root length. However, both medium (16-20 cm) and long (22-26 cm) cuttings gave satisfactory results. Our results are similar to those obtained by Henry *et al*. (1992) who reported that cutting length positively affected root count and root length, but not rooting percentage in *Juniperus virginiana*. Our findings also agree with those obtained in *Actinidia arguta* by Beyl *et al*. (1995) who attributed the efficacy of longer cuttings in inducing higher rooting performances to high carbohydrate reserves relatives to shorter cuttings.

To our knowledge, this is the first report concerning the beneficial effects of basal heating on root formation in *P. rubra* cuttings. A profuse root system derived from favourable rooting conditions and a correct choice of cutting material results in optimal transplant response and better growth than cuttings with a poor rooting system (Dirr, 2006).

According to these indications and based on our results we suggest that, among *P. rubra* rooting techniques applied in the Mediterranean region, basal heat along with the use of medium/long size cuttings can play a major role in improving rooted cutting quality.

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