**EFFECTS OF BASAL HEAT AND CUTTING LENGTH ON *PLUMERIA RUBRA* L. ROOTING**

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**Abstract**

Root development of hardwood cuttings of *Plumelia 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 was 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.

**Key words:** adventitious roots, bottom heat, cutting size

Running title: Clonal propagation of *Plumeria rubra*

**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. *Plumelia rubra* 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 1987, 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 (RCB) with four replications, six treatments [three cutting lengths x two rooting medium temperatures (heated bench vs unheated bench)] and ten cuttings per replication. After 7 weeks, cuttings were evaluated for percent rooting, 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* < 0.01) (Petersen 1985). Single plants were transferred to each plastic pot (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 (Table 1). According to Bryant (2003), rooting in *Plumeria* can range from 50 to 75%; in a study performed in Hawaii, Hata et al. (1994) 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. Our positive response could be related to diverse genotypes studied. Roots were evenly distributed at the cut basal portion of the cutting (Fig. 1). Only two of the 240 cuttings died (data not shown), and every surviving cutting produced roots and leaves.

Number of roots per cutting was strongly affected by basal heating (Table 1). Cuttings exposed to constant temperature of 28 ± 3°C averaged 33 roots, compared to 18 roots for cuttings placed in the unheated bench. Bottom 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 and up to 7°C greater for those from warm climates (Kester 1970, Dykeman 1976); whereas suboptimal 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). On this respect, *P. rubra* rooting requirement might 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) produce more lateral and longer roots than those grown in unheated benches (Chen and Stamps 2006).

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). Medium size cuttings (16-20 cm long) averaged 26 roots. There was no discernible relationship between basal heating and cutting length.

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. 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 (Table 1).

In conclusion, the typical *P. rubra* clone found in Palermo showed 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. We suggest that 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. Propagated plants grew vigorously, were morphological normal and began to flower during summer 2013.

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**Legend to figures:**

**Fig. 1.** *Plumeria rubra* cuttings with adventitious roots after 7 weeks in bottom-heated bench at constant temperature of 28 ± 3°C.

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| **Table 1. Effects of basal heat and cutting length on *Plumeria rubra* rooting** | | | | |
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| Treatment | Rooting | Root | Root length | Bud growth |
| Basal heat (BH) | (%) | number | cm. | cm. |
| **₋** | 97.6 ± 3.5 a | 18.3 ± 2.1 b | 7.7 ± 1.7 b | 1.9 ± 1.1 b |
| **₊** | 98.4 ± 4.3 a | 33.0 ± 3.3 a | 10.5 ± 1.0 a | 3.5 ± 0.4 a |
| Cutting length (CL) |  |  |  |  |
| (cm) |  |  |  |  |
| 10-14 | 98.1 ± 1.0 | 22.4 ± 0.8 b | 7.8 ± 0.8 b | 2.7 ± 1.6 a |
| 16-20 | 98.2 ± 1.2 | 25.7 ± 0.5 ab | 8.6 ± 0.3 ab | 2.6 ± 1.4 a |
| 22-26 | 98.5 ± 1.8 | 28.9 ± 1.1 a | 11.2 ± 0.5 a | 2.9 ± 1.1 a |
| BH x CL | NS | NS | NS | NS |
| Values represent mean ± standard error. In each column, means followed by the same | | | | |
| letters are not significantly different at the p < 0.01 level by Fisher's protected least | | | | |
| significant difference test. | | | | |
| NS = Non significant . | | | | |