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Studies on the Rooting and the Consequent Plant Growth on the Stem Cuttings of *Thunbergia grandiflora*, (Roxb ex Rottl.) Roxb 1- Effect of Different Planting Dates

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Abstract: This study was conducted in a glasshouse at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Giza, Egypt during the two successive seasons of 2004/2005 and 2005/2006. Semihardwood stem cuttings of *Thunbergia grandiflora* (25 cm in length, defoliated, with 3 nodes) were collected and planted on 21st March, 21st June, 21st September and 21st December. The results recorded 4 months after each planting date showed that planting the cuttings on 21st March produced significant increases in rooting percentage, number of roots/plant as well as number of leaves, fresh and dry weights of leaves and dry weight of branches/plant compared to the other planting dates. The highest total carbohydrates content, C/N ratio and total soluble indoles content, as well as the lowest content of total soluble phenols were recorded in the basal parts of the stem cuttings planted on 21st March, whether before planting or 30 days after planting. Data recorded four months after planting showed that the early planting date (21st March) gave the highest total carbohydrates content in the leaves, compared to the other dates. Planting date at which the cuttings had a high C/N ratio gave a high rooting percentage. From the results obtained, it can be recommended that, the early planting date (21st March) was positive in improving the rooting and the vegetative growth on *Thunbergia grandiflora* stem cuttings than did the other investigated planting dates.

Key words: *Thunbergia grandiflora* · cutting · planting date · rooting

INTRODUCTION

Thunbergia grandiflora, (Roxb ex Rottl.) Roxb. belongs to family Acanthaceae and known as Bengal clock vine or Blue trumpet vine. The plant is a vigorous, woody-stemmed, evergreen, perennial and twining climber. Its beautiful, large, trumpet-shaped, pale to deep violet-blue flowers appear most of the year [1]. It can be used for landscape purposes as a climber against fences or on pergolas and arbours [2].

Research work conducted on the propagation of *Thunbergia grandiflora* has revealed that stem cuttings are hard to produce adventitious roots. In this respect, Mathad and Nalwadi [3] found that rooting % of *Thunbergia grandiflora* stem cuttings was only 20% in coarse sand.

Several environmental factors affect the rooting of cuttings, including humidity, temperature and light [4]. This may be related to changes in the endogenous plant growth regulators or carbohydrate concentrations [5]. Several researchers have investigated the influence of planting time on the rooting of stem cuttings and plant growth such as Darwesh [6] on *Ficus retusa* "Hawaii"; DengXiong *et al*. [7] on *Quisqualis indica* and Rowezak, [8] on *Ficus benjamina* var. *exotica*). In general, they showed that the plants gave the best results concerning the rooting and the vegetative growth when the cuttings were planted during March and April. However, some species gave the best results when the cuttings were planted in July and August as reported by YongKweon and KiSun [9] on *Abeliophyllum distichum*, or in January as reported by Rowezak [8] on *Ficus retusa* var. "*Hawaii*".

Therefore, the present study was conducted to investigate the effect of different planting dates on the rooting of defoliated *Thunbergia grandiflora* stem cuttings, as well as on the growth and the chemical composition of the consequent plants.

MATERIALS AND METHODS

This study was conducted in a glasshouse at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the two successive seasons of 2004/2005 and 2005/2006.

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Table 1: Physical properties of the sand used in the potting mixture, as well as the chemical characteristics of the peat moss + sand mixture during 2004/2005 and 2005/2006 seasons

Physical properties of the sand					
Texture	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Field capacity (%)
Sand	64.17	30.42	3.66	1.75	6.5
Chemical characteristics of the peat moss + sand mixture					
			Macro-nutrients content (%)		
Organic matter (%)	EC (dS/m)	pH	N	P	K
65.4	0.9	5.9	0.64	0.32	0.78

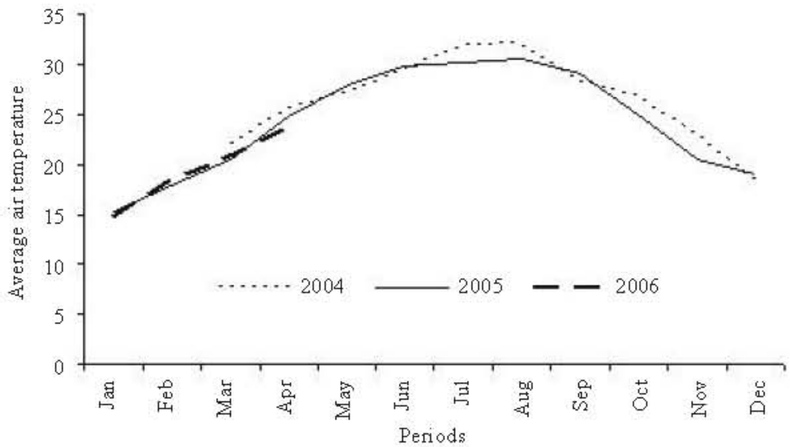

Fig. 1: The average of air temperature under the experimental condition (polyethylene sheet) during the period of the study

Semihardwood stem cuttings of *Thunbergia grandiflora* (25 cm in length, with 3 nodes) were taken on 21st March, 21st June, 21st September and 21st December of the years 2004 and 2005. The cuttings were defoliated, then planted in 25-cm diameter plastic pots (4 cuttings/pot) filled with a mixture of peat moss and sand (3:1, v/v).

The layout of the experiment was a randomized complete blocks design with three replicates for each treatment. Each replicate comprised five pots. In addition, eight spare cuttings (two pots) / replicate were used for the chemical analyses (and that were not included in the statistical analysis). The pots were placed on benches under a frame of wires covered with polyethylene sheets (110 cm high, 120 cm wide and 6.50 m long). The physical properties of the sand used in the potting mixture, as well as the chemical characteristics of the mixture are shown in Table 1. The minimum and maximum daily air temperatures under the experimental condition (polyethylene) were recorded during the period of the study using a Mini Max Recording Thermometer and the mean of air temperature throughout the duration of the experiment was calculated (Figure 1). The pots were irrigated every 3 days during the period from March to September and every 5 days during the period from October till February.

Fresh samples were taken before planting from the basal 2 cm of cuttings. Samples were chamically analyzed to determine total soluble indoles content (mg/g fresh matter) as described by Larsen *et al.* [10] and total soluble phenols content (mg/g fresh matter) according to Swain and Hillis [11]. In addition, chemical analysis of dried samples of the basal 2 cm of cuttings was conducted before planting to determine total carbohydrates content (% of dry matter) as described by Dubois *et al.* [12]. The total nitrogen content (% of dry matter) was determined according to Pregl [13] after digestion the dried samples using the method described by Piper [14], also, the C/N ratio was calculated. After 30 days from planting (during root emergence), the chemical analyses of the basal 2 cm of cuttings fresh and dried samples were conducted to determine the same above mentioned chemical characteristics.

Four months after each planting date, the plants per each replicate were dug out to record the following characteristics: rooting percentage, root length, number of roots/plant, fresh and dry weights of roots (g)/plant, plant height (cm), number of leaves/plant as well as fresh and dry weights of leaves and branches (g)/plant. Chemical analysis of the dried leaves was conducted to determine total carbohydrates content (% of dry matter) as described by Dubois *et al.* [12].

The data of the vegetative characteristics were subjected to an analysis of variance and the means were compared using the "Least Significant Difference (L.S.D.)" test at the 5% level, as described by Little and Hills [15]. The rooting percentage data were arcsine transformed and the transformed data were statistically analyzed.

RESULTS AND DISCUSSION

1- Rooting percentage: Data presented in Table 2 showed, in general, significant differences between the effects of the different planting dates on the rooting percentage of *Thunbergia grandiflora* stem cuttings in both seasons. Stem cuttings planted on 21st March had significantly higher rooting percentages (36.7% and 40.0% in the first and second seasons, respectively), as compared to the other planting dates, followed by those planted in September. Similar results have been reported by Karaguzel [16] on *Bougainvillea glabra*, Agnihotri and Ansari [17] on *Bambusa vulgaris* var. *striata* and *Dendrocalamus strictus*, DengXiong *et al.* [7] on *Quisqualis indica* and Hussein [18] on *Beaumontia grandiflora*.

On the other hand, the lowest rooting percentage was obtained when the stem cuttings were planted in June. The data recorded on the content of total carbohydrates in the cuttings before planting (Table 4) confirm this findings, since the lowest total carbohydrates content was estimated in the cuttings before planting in June, this was in relation to the lowest rooting percentage. The reduction in the rooting percentage that was observed on June cuttings may be attributed to that the plants tended to flower at this time, causing the utilization of auxins for floral bud development and the depletion of the carbohydrate reserves within the plant [19]. In this respect, Janick [4] mentioned that the vegetative shoots are likely to root better than the flowering shoots which may be related to auxin levels and the amount of stored food. Heller *et al.* [20], on *Coleonema aspalathoides* and Hussein [18] on *Beaumontia grandiflora* found that the rooting ability of stem cuttings declined during the plants' natural flowering season. Also, HeiChing and YuSen [21] reported that high temperature and high humidity in summer decreased the rooting of *Bougainvillea glabra*.

The relatively low rooting percentage of December cuttings may be attributed to the low temperature of the rooting medium since rooting of most species requires a temperature of about 24°C, in order to stimulate cell division in the rooting area [4].

2- Root characteristics: The parameters of roots formed on *Thunbergia grandiflora* stem cuttings were measured as root length, number of roots/plant, as well as the fresh and dry weights of roots/plant. Generally, different planting dates were significantly differed in their effects on root characteristics (Table 2). In both seasons,

Table 2: Effect of different planting dates on the rooting percentage, root length, number of roots/plant, as well as the fresh and dry weights of roots/plant of *Thunbergia grandiflora* during 2004/2005 and 2005/2006 seasons

Planting dates	*Rooting percentage	Root length (cm)	Number of roots/plant	Fresh weight of roots/plant (g)	Dry weight of roots/plant (g)
First season (2004/2005)					
21 March	36.7 a	8.5	4.5	3.80	0.84
21 June	20.0 c	9.9	4.0	4.95	0.89
21 September	28.3 b	5.8	3.3	3.20	0.51
21 December	21.7 c	4.6	3.0	2.60	0.50
L.S.D. (0.05)	----	0.6	0.4	0.32	0.09
Second season (2005/2006)					
21 March	40.0 a	7.6	5.5	4.50	0.90
21 June	21.7 c	9.8	4.6	5.80	1.33
21 September	26.7 b	6.1	4.2	3.80	0.57
21 December	25.0 b	5.5	2.4	2.40	0.43
L.S.D. (0.05)	----	0.8	0.3	0.38	0.06

* Within the columns for rooting percentage, means sharing one or more letters are insignificantly different at the 5% level, according to the "Least Significant Difference" test

Table 3: Effect of different planting dates on plant height, fresh and dry weights of branches/plant, number of leaves/plant, as well as the fresh and dry weights of leaves/plant of *Thunbergia grandiflora* during 2004/2005 and 2005/2006 seasons

Planting dates	Plant height (cm)	Fresh weight of branches/plant (g)	Dry weight of branches/plant (g)	Number of leaves/plant	Fresh weight of leaves/plant (g)	Dry weight of leaves/plant (g)
			First season (2004/2005)			
21 March	30.6	19.8	5.06	5.4	3.91	0.59
21 June	36.4	22.0	4.16	4.2	3.11	0.40
21 September	26.0	17.5	3.50	3.6	2.83	0.40
21 December	26.2	16.8	3.02	2.0	2.49	0.30
L.S.D. (0.05)	2.8	2.1	0.45	0.5	0.29	0.06
			Second season (2005/2006)			
21 March	25.5	22.0	5.71	4.9	4.13	0.74
21 June	28.0	23.8	5.06	4.1	3.86	0.54
21 September	23.0	18.4	3.86	3.0	2.40	0.29
21 December	21.4	16.5	3.13	2.5	2.30	0.30
L.S.D. (0.05)	2.4	1.8	0.39	0.4	0.26	0.08

significant higher values were achieved for root length, as well as the fresh and dry weights of roots/plant when the stem cuttings were planted in June, as compared with those of the other planting dates, followed by planting in March. Meanwhile, cuttings planted in March gave significant higher number of roots/plant compared to that of any other planting date, followed by that of cuttings planted in June. These stimulative effects on root growth may be attributed to the high temperature and to the increase in the photosynthetic rate during the spring and summer months, which leads to produce more carbohydrates content [22]. Similar results were obtained by El-Malt [23] on *Ficus benjamina* var. *exotica* and DengXiong *et al.* [7] on *Quisqualis indica*, who recorded an increase in root growth during the spring months. Also, Hussein [18] on *Beaumontia grandiflora* recorded an increase in root growth during the summer months.

Delaying the cuttings propagation date to September or December for both seasons gave significant lower values for all root parameters, compared to the values obtained for the propagation in March or June. The lowest values in both seasons were recorded when the cuttings were planted in December.

3- Plant vegetative characteristics: It can be noticed that from Table 3 that the different planting dates showed obvious differences concerning their effects on all the vegetative characteristics (plant height, number of leaves/plant, as well as the fresh and dry weights of branches and leaves/plant) recorded four months after planting. In both seasons, cuttings planted at the earliest date (21st March) gave significant higher values for most of the vegetative growth characteristics (dry weight of branches/plant, number of leaves/plant as well as the fresh and dry weights of leaves/plant), compared to those of cuttings planted at any other date. Moreover, the values recorded for most of the vegetative characteristics were decreased steadily as the planting date delayed after March to June, September or December. On the other hand, the cuttings planted in June gave increases in the plant height and the fresh weight of branches with significant differences as compared to those of the other planting dates, followed by those planted in March, whereas cuttings planted in September and December gave the lowest values.

The favourable effect of planting the cuttings in spring (March) on plant vegetative growth is similar to that obtained by Darwesh [6] on *Ficus retusa* "Hawaii", Rowezak [8] on *F. benjamina* var. *exotica* and *F. retusa* "Hawaii" and Hussein [18] on *Beaumontia grandiflora.*

The relative reduction in most of the vegetative traits of plants formed on cuttings planted in June, compared to that resulted from cuttings planted in March may be related to the poor root formation on cuttings planted in June (Table 2), which adversely affects the uptake of water and nutrients or to the excessively high temperatures during July and August, which led to a decrease in the photosynthetic rate. As mentioned by Devlin and Witham [22], photosynthesis increases with the increase in temperature, until the optimum temperature, above that it is inhibited. Thus the reduction in the vegetative growth of plants formed from cuttings planted in September or December may be attributed to the cold weather (i.e. temperatures were lower than the optimum) during the autumn and the winter, which reduced the photosynthetic rate.

Table 4: Effect of different planting dates on the total carbohydrates content, total nitrogen content, the C/N ratio and the total soluble indoles and total soluble phenols contents at the base of stem cuttings as well as the total carbohydrates content in the leaves of *Thunbergia grandiflora* during 2004/2005 and 2005/2006 seasons

	Chemical composition of basal part of cuttings				
	Before planting				
Planting dates	Total carbohydrates content (% of dry matter)	Total nitrogen content (% of dry matter)	C/N ratio	Total soluble indoles content (mg/g fresh matter)	Total soluble phenols content (mg/g fresh matter)
First season (2004/2005)					
21 March	26.8	2.14	12.5	0.51	0.70
21 June	23.5	2.24	10.5	0.38	0.82
21 September	25.2	2.27	11.1	0.34	0.91
21 December	23.8	2.05	11.6	0.25	0.96
Second season (2005/2006)					
21 March	24.1	1.96	12.3	0.48	0.65
21 June	20.9	2.20	9.5	0.42	0.70
21 September	23.8	2.25	10.6	0.30	0.84
21 December	22.1	2.05	10.8	0.26	0.92

	Chemical composition of basal part of cuttings					
	30 days after planting					
Planting dates	Total carbohydrates content (% of dry matter)	Total nitrogen content (% of dry matter)	C/N ratio	Total soluble indoles content (mg/g fresh matter)	Total soluble phenols content (mg/g fresh matter)	Total carbohydrates content in the leaves (% of dry matter), 4 months after planting
First season (2004/2005)						
21 March	24.6	1.84	13.5	0.40	0.65	22.5
21 June	20.5	1.92	10.7	0.31	0.70	21.1
21 September	21.1	1.90	11.1	0.29	0.85	19.6
21 December	23.5	1.82	12.9	0.25	0.88	19.5
Second season (2005/2006)						
21 March	23.5	1.69	13.9	0.42	0.63	23.4
21 June	20.0	2.11	9.5	0.34	0.66	22.9
21 September	21.7	2.07	10.5	0.26	0.75	20.1
21 December	20.8	1.93	10.8	0.24	0.80	19.5

4- The chemical composition of the basal part of cuttings:

a- Total carbohydrates content, total N content and the C/N ratio: The results recorded in the two seasons (Table 4) showed that the bases of cuttings taken on 21st March had the highest contents of total carbohydrates (whether before planting, or after 30 days from planting), compared to those taken at the other dates, followed by those taken on 21st September, 21st December and 21st June (in most cases).

The high total carbohydrates content in cuttings planted in March may be the reason for the increase in rooting percentage of these cuttings, as shown in Table 2. This agreed with those found by YongKweon and KiSun [9] on *Abeliophyllum distichum* and Hussein [18] on *Beaumontia grandiflora*, who reported that cuttings which rooted well had relatively high content of total carbohydrates. The data in Table 4 showed that, in both seasons, the N content at the bases of cuttings (before or after planting) was higher in cuttings taken in June or September, than in cuttings taken in March or December. Also, it can be seen from the data in Table 4 that before planting, cuttings taken in September had the highest N content at their bases, but after 30 days from planting, cuttings taken in June gave the highest values. The total carbohydrates and total N contents in the basal parts of the cuttings were decreased at 30 days after planting, compared with the values recorded before planting. This is in agreement with the findings of Mohamed [24] on *Carya illinoensis* and Hussein [18] on *Beaumontia grandiflora.* The data in Table 4 also showed that the C/N ratio followed a similar trend in both seasons (before and after planting), giving the highest values in cuttings taken in March, followed by cuttings bases taken in December, whereas those taken in June gave the lowest values. These results indicate that the C/N ratio may be an important factor influencing the rootability of cuttings, since the values of C/N ratio were positively related to the rooting percentage around the year, as previously mentioned in Table 2. This conclusion confirmed by the findings of El-Boraie [25] on *Gardenia jasminoides*, Mahros [26] on *Bougainvillea glabra* var. *sanderiana*, *B. glabra* var. *variegata* and *B. spectabilis* "Snow White" and Hussein [18] on *Beaumontia grandiflora*.

b- Total soluble indoles content: The total soluble indoles content at the bases of *Thunbergia grandiflora* cuttings (before planting, or 30 days after planting) was different according to the planting date (Table 4). In both seasons, cuttings planted in March had the highest values. This result indicates that the total soluble indoles content could be one of the factors affecting the rootability of cuttings, since cuttings taken in the March batch gave the highest rooting percentage (Table 2). These results confirm the findings of YongKweon and KiSun [9] on *Abeliophyllum distichum* Nakai and Hussein [18] on *Beaumontia grandiflora*, who reported that cuttings which rooted well had a relatively high content of endogenous IAA.

On the other hand, delaying the planting date after 21st March to 21st June, 21st September or 21st December caused a gradual decrease in the recorded values. Although the total soluble indoles content was relatively higher in cuttings taken in June than that of cuttings taken in September or December, the rooting percentage of cuttings planted in September or December was higher than that planted in June. This could be related to the lower total carbohydryates content and C/N ratio in the cuttings planted in June, compared to those of cuttings planted in September or December.

Within each batch, the total soluble indoles content in the basal parts of cuttings were mostly lower after planting than those recorded before planting. This result is in agreement with the findings of Mohamed [24] on pecan, Abo-El-EZ [27] on mango, avocado, annona and papaya and Hussein [18] on Herald's trumpet.

c- Total soluble phenols content: The results of the total soluble phenols content at the cutting bases (Table 4) were opposite to those of the total soluble indoles content. In both seasons, delaying the planting time after 21st March to 21st June, 21st September or 21st December caused a gradual increase in the recorded values (whether before planting, or 30 days after planting), thus, the highest level was obtained with December planting date. The results (Table 2) indicated that the rooting percentage was adversely affected by the total soluble phenols content in the cuttings, since the highest rooting percentage (in March) was associated with the lowest total soluble phenols content. These results are in agreement with the findings of Hussein [18], who mentioned that the highest rooting percentages of *Beaumontia grandiflora* cuttings was associated with the lowest levels of total phenols in the basal parts of the cuttings.

On the other hand, the cuttings planted in June (which had a lower total soluble phenols content compared to those planted in September or December) gave lower rooting percentage than cuttings planted in September or December. This may be related to the higher total carbohydrates content and C/N ratio in cuttings planted in September or December than in cuttings planted in June.

In general, the total soluble phenols content in the basal parts of the cuttings was decreased at 30 days after planting, compared to the values before planting. This result is in agreement with the findings of Mohamed [24] on pecan, Abo-El-EZ [27] on mango, avocado, annona and papaya and Hussein [18] on herald's trumpet.

As to the chemical composition of the basal parts of cuttings, it is worth to note that the increase in rooting percentage was not mainly associated with the increase in the total soluble indoles content or the decrease in the total soluble phenols content, but was mainly associated with the increase in the total carbohydrates content and the C/N ratio. The increase in temperature during the summer season may explain the increase in root parameters and some of the vegetative characteristics, as previously discussed (Tables 2 and 3). Generally, it can be said that the rooting percentage, root growth and vegetative growth were directly and indirectly affected by the chemical composition of the cuttings (which varied in mother plants according to different seasons and growth stage), environmental factors and the interaction between them.

5- The Total carbohydrates content in the leaves: Planting *Thunbergia grandiflora* stem cuttings at different dates showed different total carbohydrates contents in the leaves of the growing plants (Table 4). In both seasons, the highest value was obtained when the cuttings were planted at the earliest date (21st March). Similar results were obtained by Darwesh [6] on *Ficus retusa* "Hawaii" and Hussein [18] on *Beaumontia grandiflora*. The recorded values were steadily decreased as the planting date was delayed after March to June, September or December. Thus, the early planting date (21st March) gave the highest total carbohydrates content in the leaves compared to the other planting dates. This may be caused by the promoting effect of warm temperature in spring on photosynthesis. In this regard, Devlin and Witham [22] mentioned that photosynthesis reaches its highest level at a critical optimum temperature, resulting in the highest carbohydrates content. Also, they reported that under normal conditions, water absorption takes place through the root system. However, the optimum temperature seemed to be in spring for the subjected plants. Thus, the relatively vigorous root growth on cuttings planted on 21st March (spring) causes a high efficiency of the water uptake needed for photosynthesis and other physiological activities which have direct impact on plant growth.

CONCLUSION

The present findings indicated the possibility of improving the rooting and the vegetative growth in *Thunbergia grandiflora* throughout planting the stem cuttings on 21st March. This conclusion is supported by the results obtained as the early planting date (21st March) exhibited more improvement in most of the studied characteristics, compared to the other planting dates, which in turn reflect on the growth and behaviour of the plants.

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