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EFFECT OF PLANTING DATES AND INDOLE-BUTYRIC ACID ON ROOTING OF *BEAUMONTIA GRANDIFLORA* WALLICH. CUTTINGS AND CONSEQUENT PLANT GROWTH

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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. The study included two experiments. The first experiment was carried out during the 1999/2000 and 2000/2001 seasons, with the aim of investigating the effect of different planting dates on the rooting of *Beaumontia grandiflora* Wallich. cuttings, as well as consequent plant growth and chemical composition. Semihardwood stem cuttings (15 cm long, defoliated, with 3 nodes) were planted on 21st March, 21st June, 21st September and 21st December.

Results recorded 4 months after each planting date showed that:

- Planting the cuttings in March gave the highest rooting percentage, the highest vegetative growth of the resulting plants (in terms of plant height, number of leaves, as well as the fresh and dry weights of leaves and stems/plant). The highest total carbohydrates content, C/N ratio and total soluble indoles content, as well as the lowest total soluble phenols content were recorded in the cuttings planted in March, whether before planting or in the basal parts of cuttings after 30 days from planting. Moreover, plants formed on cuttings planted in March had the highest total carbohydrates content in the leaves, compared to plants formed on cuttings planted on other dates.
- Planting in March or June gave the best root growth in terms of root length, number of roots/plant, as well as the fresh and dry weights of roots/plant.
- A positive relation was recorded between seasonal variations in the C/N ratio and the rooting percentage of cuttings, i.e. planting dates at which the cuttings had a high C/N ratio also gave a high rooting percentage.

The second experiment was conducted during the 2001 and 2002 seasons, with the aim of investigating the feasibility of using IBA for improving the rooting of cuttings planted in March, as well as the subsequent vegetative plant growth and chemical composition. The bases of the cuttings taken in March were immersed in an IBA solution at concentrations of 0 (control), 1000, 2000, 3000 and 4000 ppm for 10 seconds prior to planting.

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Results recorded four months after planting showed that:

- IBA at 3000 ppm gave the highest rooting percentage. Also, increasing IBA concentration up to 3000 ppm significantly increased most of the root growth parameters and vegetative growth characteristics.
- IBA at 3000 or 4000 ppm gave the highest contents of total soluble indoles at the base of cuttings after planting, and the highest total carbohydrates in the leaves of resulting plants.
- No logical relation was detected between the C/N ratio in basal parts of cuttings after planting and the increase in rooting percentage as a result of increasing IBA concentrations up to 3000 ppm.

From the above results, it can be recommended that for the best rooting and most vigorous vegetative growth of *Beaumontia grandiflora*, cuttings should be dipped in an IBA solution at 3000 ppm before planting in March.

Key words: *Beaumontia grandiflora*, Cutting, IBA, Planting dates, Rooting, Seasonal variation

INTRODUCTION

Beaumontia grandiflora Wallich. (Family: Apocynaceae), known as Herald's trumpet, is a vigorous, evergreen, twining climber native to the area from India to Vietnam. Its leaves are broadly oblong-ovate, downy, glossy deep green (when mature). Its trumpet-shaped, fragrant, white flowers (8-13 cm long) are borne in terminal and axillary corymbs from late spring to summer (**Brickell, 1996**). It has high heat requirements, and thrives in subtropical areas, where mean daily maximum temperatures may reach 41-42° C. It is quite a rare plant which may be difficult to find. However, its potential uses for landscape purposes include growing it as an unusual specimen plant in the garden, as a climber against a fence, or as a perfumed plant for a summer garden (**Rudjiman, 1987**). The propagation of *B. grandiflora* by stem cuttings was investigated by **Bhattacharjee and Balakrishna (1990)**, who reported that IBA or NAA, each at 4000 ppm, failed to improve the rooting percentage of two-leaf cuttings planted in sand.

Several environmental factors affect the rooting of cuttings, including humidity, temperature and light (**Janick, 1986**). Thus, seasonal variations in these factors may have a considerable influence on the rooting ability of cuttings, by causing changes in the endogenous plant growth regulators or carbohydrate concentrations (**Day and Loveys, 1998**). Several researchers have investigated the influence of the timing of planting on the rooting of cuttings, and on plant growth [**Darwesh (2000)** on *Ficus retusa* "Hawaii", **DengXiong *et al* (2000)** on *Quisqualis indica*, and **Rowezak (2001)** on *Ficus benjamina* var. exotica]. In general, these plants gave the best rooting and vegetative growth when the cuttings were planted during the spring months (March and April). However, some species gave the best results when the cuttings were planted in July and August (**YongKweon and KiSun, 1996 a,** on *Abeliophyllum distichum*), or in January (**Rowezak, 2001,** on *Ficus retusa* "Hawaii").

The adventitious roots which are developed on cuttings, directly from the stem or from the callus tissue near a cut surface, are important in plant propagation in the rooting of stem cuttings. In young stems, the cells that form the root primordium are derived from the interfascicular parenchyma, while in older stems from a vascular ray **(Pandey, 1979)**. Cells from which the roots are initiated renew their cell division activity with stimulation from auxins. Auxin levels are closely associated with adventitious rooting of stem cuttings **[Janick (1986)**, and **Taiz** and **Zeiger (1998)]**. However, the effectiveness of different types and levels of auxin differs from one species to the other. In several ornamental plants, the use of indole-3-butyric acid at concentrations ranging from 2000 to 4000 ppm proved to have a beneficial effect on the rooting of stem cuttings [**Bhattacharjee and Balakrishna (1990 and 1991)** on *Hiptage madhablota*, *Ipomoea beraviensis*, *Clerodendrum splendens*, *Ipomoea tuberosa*, *Tecoma jasminoides*, *Thunbergia grandiflora* and *Vernonia elaegnifolia*, **El-Boraie (1998)** on *Gardenia jasminoides*, **Schoellhorn (2001)** on *Dichorisandra thyrsiflora* and *Cestrum elegans*, **Sharma *et al* (2002, a)** on *Gardenia lucida*, and **Sharma *et al* (2002, b)** on *Acalypha wilkesiana* cv. Tahiti].

This study was conducted to investigate the effect of seasonal variations (planting dates) and IBA (indole-3-butyric acid) treatments on the rooting of defoliated *Beaumontia grandiflora* cuttings, as well as the growth and chemical composition of the resulting plants.

MATERIAL AND METHODS

This study was conducted in a semi-shaded uncontrolled glasshouse (well ventilated during summer to avoid any excessive rise in air temperature) at the Experimental Nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the period from 1999 to 2002. The study included two separate experiments:

Experiment I: Effect of planting dates on the rooting of *Beaumontia grandiflora* cuttings, and subsequent plant growth.

This experiment was conducted during the two successive seasons of 1999/2000 and 2000/2001, with the aim of determining the best time for propagating *Beaumontia grandiflora* Wallich. using semihardwood cuttings. The cuttings (15 cm long, defoliated, with 3 nodes) were taken on 21^{st} March, 21^{st} June, 21^{st} September and 21^{st} December of the years 1999 and 2000. The bases of the cuttings were dipped in hot water (40° C) for 5 seconds to coagulate the latex prior to planting in 25-cm diameter plastic pots (4 cuttings/pot). The pots were filled with a mixture of peat moss and sand (3:1, v/v), and 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 preparation of 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 polyethylene were recorded using Mini Max Recording Thermometers, and the mean temperatures for the duration of the experiments (Figure 1) were calculated. The pots were watered daily during the spring and summer months (from March till September), and every 2 days during the

Table 1. Physical properties of the sand used in preparation of the potting mixture of *Beaumontia grandiflora* during the period from 1999 to 2002, as well as the chemical characteristics of the peat moss + sand mixture

Physical properties of the sand							
Texture	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	CEC (meq/ 100 g)	Field capacity (%)
Sand	70.39	24.20	3.81	1.60	0.56	1.9	6.5
Chemical characteristics of the peat moss + sand mixture							
Organic matter (%)	EC (dS/m)	pH	Macro-nutrients content (%)				
			N		P		K
68.9	1.1	5.8	0.7		0.3		0.8

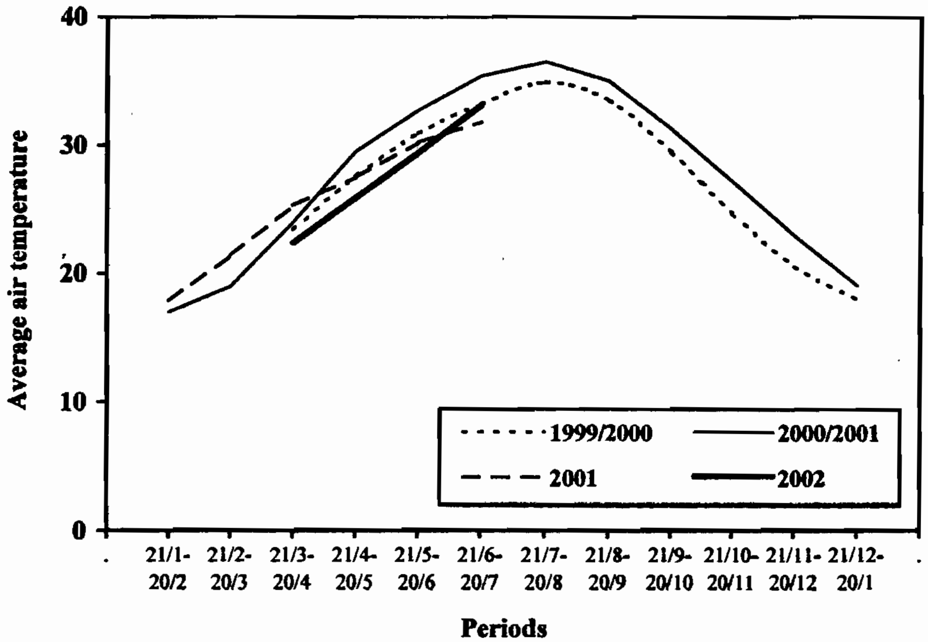

Fig. 1. Average air temperature during the study

autumn and winter months (from October till February).

The contents of total soluble indoles (using the method described by **Larsen *et al* 1962**) and total soluble phenols (according to **Swain and Hillis, 1959**) were determined in fresh samples taken before planting from the basal parts of cuttings. Also, chemical analysis of dry samples of basal parts of cuttings was conducted before planting to determine their total carbohydrates content (using the method described by **Dubois *et al* 1956**). The total nitrogen contents was also conducted (according to **Pregl, 1945**) after sample digestion (using the method described by **Piper, 1947**), and the C/N ratio was calculated. After 30 days from planting (during root emergence), chemical analysis of the basal 2 cm of fresh and dry cutting samples was conducted to determine the same chemical characteristics that had been determined before planting.

Four months after each planting date, the plants were dug out, and the data were recorded on rooting, and on plant vegetative growth. The recorded data included rooting percentage, average root length, number of roots/plant, plant height, number of leaves/plant, as well as the fresh and dry weights of leaves, stems and roots/plant. Chemical analysis of the dried leaves was also conducted to determine their total carbohydrates contents.

Experiment II: Effect of IBA concentrations on the rooting of *Beaumontia grandiflora* cuttings, and subsequent plant growth

From the results obtained in the first season of Experiment I, it was concluded that propagation in March gave the best results in terms of rooting and most vegetative growth parameters. Thus, Experiment II was conducted during the two successive seasons of 2001 and 2002, with the aim of investigating the feasibility of using IBA (indole-3-butyric acid) for improving the rooting of *Beaumontia grandiflora* semihardwood cuttings taken in March, and the subsequent vegetative growth of the resulting plants. The cuttings (15 cm long, defoliated, with 3 nodes) were taken on 21st March, 2001 and 2002, and their bases were dipped in hot water (40° C) for 5 seconds to coagulate the latex prior to dipping for 10 seconds in a solution of IBA (indole-3-butyric acid) in 40% ethyl alcohol, at concentrations of 1000, 2000, 3000 and 4000 ppm. In addition, control cuttings were dipped in 40% ethyl alcohol for 10 seconds. Immediately after treatment, the cuttings were planted (4 cuttings/pot) in 25-cm diameter plastic pots. The pots were filled with the same growing medium and were placed under similar conditions as described in Experiment I. The pots were irrigated daily till the termination of the experiment four months after planting the cuttings. At the termination of the experiment, the recorded data included the same parameters mentioned in Experiment I.

The layout of both experiments was a randomized complete blocks design with 3 replicates. Each replicate consisted of 20 cuttings/treatment, in addition to 4 spare cuttings/treatment used for determination of the chemical composition of the base of the cuttings (and that were not included in the statistical analysis).

The data on the vegetative growth characteristics were subjected to 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 (1978)**. The rooting percentage data were arcsine transformed, and the transformed data were statistically analysed.

RESULTS AND DISCUSSION

Experiment I: Effect of planting dates on the rooting of *Beaumontia grandiflora* cuttings, and subsequent plant growth

1- Rooting percentage

The data presented in Table (2) show that the rooting percentage of *Beaumontia grandiflora* cuttings was significantly affected by the planting date. In both seasons, cuttings planted in March had the highest rooting percentage (56.7% and 58.3% in the first and second seasons, respectively), followed by those planted in September, whereas the lowest rooting percentage was obtained when the cuttings were planted in June. Similar results have been reported by **Karaguzel (1997)** on *Bougainvillea glabra*, **Agnihotri and Ansari (2000)** on *Bambusa vulgaris* var. striata and *Dendrocalamus strictus*, and **DengXiong *et al* (2000)** on *Quisqualis indica*.

The reduction in the rooting percentage that was observed in cuttings planted in June can be easily explained, since the plants tended to flower at this time, causing the utilization of auxins for floral bud development (**Taiz and Zeiger, 1998**), and the depletion of the carbohydrate reserves within the plant. This conclusion is similar to that reached by **Janick (1986)**, who mentioned that vegetative shoots are likely to root better than flowering shoots, and this may be related in part to auxin levels and the amount of stored food. A similar conclusion was reached by **Heller *et al* (1994)**, who found that the rooting ability of *Coleonema aspalathoides* cuttings declined during the plant's natural flowering season. The data presented in Table (4) confirm these results, since a decrease in the total carbohydrates content was recorded in cuttings taken in the summer batch (in most cases), as compared with cuttings taken in other planting dates and, as previously mentioned, this was associated with the lowest rooting percentage. Also, **HeiChing and YuSen (1999)** reported that high temperature and high humidity in summer decreased the rooting of *Bougainvillea glabra*.

Moreover, the data recorded in the first season showed that the rooting percentage of cuttings planted in March was significantly higher than that of cuttings planted at any other date, but in the second season, no significant difference was detected between the rooting percentage of cuttings planted in March and that of cuttings planted in September. Also, no significant difference was detected in both seasons between the rooting percentage of cuttings planted in June and that of cuttings planted in December, nor between the rooting percentage of cuttings planted in September and that of cuttings planted in December. The relatively low rooting percentage of cuttings planted in December may be attributed to the reduction in the 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 (**Janick, 1986**).

2- Root growth

The growth of roots formed on *Beaumontia grandiflora* cuttings (in terms of root length, number of

Table 2. Effect of planting dates on the rooting percentage, root length, number of roots/plant, as well as the fresh and dry weights of roots/plant of *Beaumontia grandiflora* during the 1999/2000 and 2000/2001 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 (1999/2000)					
21 March	56.7 a	11.5	4.0	5.39	0.86
21 June	35.0 c	12.8	4.2	5.74	0.98
21 September	45.0 b	8.0	3.5	3.85	0.70
21 December	40.0 bc	4.5	2.4	3.43	0.58
L.S.D. (0.05)	—	1.6	0.4	0.39	0.14
Second season (2000/2001)					
21 March	58.3 a	9.9	3.7	6.27	1.05
21 June	40.0 b	10.5	4.1	6.34	1.09
21 September	51.7 ab	9.1	2.9	3.43	0.54
21 December	45.0 b	8.5	1.3	3.29	0.46
L.S.D. (0.05)	—	0.9	0.6	0.28	0.09

* 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.

roots/plant, as well as the fresh and dry weights of roots/plant) was significantly affected by the planting date (Table, 2). In both seasons, the highest values for the different root growth characteristics were achieved by planting the cuttings in June, followed by planting in March, with no significant difference between the values obtained with these two planting dates. This stimulation of vigorous root growth on cuttings planted in March or June may be attributed to the relatively high temperature of the root zone, and to the increase in the photosynthetic rate as a result of the increase in air temperature (Fig. 1) during the spring and summer months (**Devlin and Witham, 1986**), which leads to the production of more carbohydrates needed for root growth. The increase in root growth during the spring months is in agreement with the findings of **El-Malt (1989)** on *Ficus benjamina* var. exotica, and **DengXiong *et al* (2000)** on *Quisqualis indica*.

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

3- Plant vegetative growth

From the data presented in Table (3), it can be noticed that the planting date of *Beaumontia grandiflora* cuttings had a significant effect on all the vegetative growth parameters (plant height, number of leaves/plant, as well as the fresh and dry weights of stems and leaves/plant) recorded four months after planting. In both seasons, cuttings planted at the earliest date (March) gave significantly higher values for most of the vegetative growth characteristics, compared to cuttings planted at any other date. Moreover, the values recorded for the different studied vegetative growth characteristics were decreased steadily as the planting date was delayed from March to June, September or December.

The relatively high growth rate of plants resulting from cuttings planted in March or June may be attributed to the increase in temperature (as shown in Fig. 1), which stimulates vegetative growth. The favourable effect of planting the cuttings in spring (March) on plant vegetative growth is similar to that obtained by **Darwesh (2000)** on *Ficus retusa* "Hawaii", and **Rowezak (2001)** on *F. benjamina* var. exotica.

The relative reduction in the vegetative growth rate of plants formed from cuttings planted in June, compared to that resulting from cuttings planted in March, may be attributed to the excessively high temperatures during the months of July and August, which led to an inhibition of photosynthesis. As pointed out by **Devlin and Witham (1986),** photosynthesis increases with the increase in temperature, until an optimum temperature is reached, above which photosynthesis is inhibited. On the other hand, the reduction in the vegetative growth rate 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 winter months, which reduced the photosynthetic rate.

4- Chemical composition of 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) show that cuttings taken in March had higher contents of total carbohydrates at base of cuttings (whether before planting, or after 30 days after planting), compared to cuttings taken at other months of the year. The increase in the 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 result is in agreement with that reported by **YongKweon and KiSun (1996, a)** on *Abeliophyllum distichum*, who found that cuttings which rooted well had relatively high contents of total carbohydrates. On the other hand, the relation between the contents of total carbohydrates in cuttings taken in June, September or December differed from one season to the other. The data in Table (4) also show that no clear trend was detected for the seasonal variations in the total N content at the bases of cuttings. Generally, the total carbohydrates and total N contents in the basal parts of the cuttings were decreased after planting, compared with the values recorded before planting. This is in agreement with the

Table 3. Effect of planting dates on plant height, fresh and dry weights of stems/plant, number of leaves/plant, as well as the fresh and dry weights of leaves/plant of *Beaumontia grandiflora* during the 1999/2000 and 2000/2001 seasons

Planting dates	Plant height (cm)	Fresh weight of stems /plant (g)	Dry weight of stems /plant (g)	Number of leaves /plant	Fresh weight of leaves /plant (g)	Dry weight of leaves /plant (g)
First season (1999/2000)						
21 March	20.1	9.61	2.84	5.7	3.5	0.58
21 June	18.5	8.00	1.87	4.5	3.4	0.46
21 September	18.2	7.10	1.47	4.1	2.8	0.41
21 December	16.4	6.95	1.43	3.6	1.9	0.23
L.S.D. (0.05)	0.4	0.31	0.06	0.4	0.3	0.03
Second season (2000/2001)						
21 March	18.5	10.40	2.50	6.9	4.2	0.75
21 June	17.6	9.01	1.72	6.5	3.8	0.53
21 September	16.5	8.55	1.54	5.4	3.0	0.36
21 December	16.0	6.87	1.19	3.1	2.5	0.34
L.S.D. (0.05)	0.5	0.23	0.09	0.3	0.5	0.02

findings of **Mohamed (1992)** on *Carya illinoensis*. However, 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 taken in September, whereas cuttings 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 recorded for the C/N ratio were positively related with the rooting percentage of the cuttings taken at different times of the year, as previously mentioned in Table (2). This conclusion is in agreement with the findings of **El-Boraie (1998)** on *Gardenia jasmino - des*, and **Mahros (2000)** on *Bougainvillea glabra* var. sanderiana, *B. glabra* var. variegata and *B. spectabilis* "Snow White".

The C/N ratio was increased after planting, as compared with the values recorded before planting. This is in agreement with the findings of **Mohamed (1992)** on *Carya illinoensis*.

b- Total soluble indoles content

The total soluble indoles content at the bases of *Beaumontia grandiflora* cuttings (before planting, and after 30 days from planting) was clearly affected by the planting date (Table, 4). In both seasons, planting the cuttings in March gave the highest values. This result indicates that the total soluble indoles content may be one of the factors affecting the rootability of cuttings since, as previously mentioned, cuttings taken in the March batch gave the highest rooting percentage (Table 2). These results confirm the findings of **YongKweon and KiSun (1996, a)** on white forsythia (*Abeliophyllum distichum* Nakai), who reported that cuttings which rooted well had a relatively high content of endogenous IAA.

On the other hand, delaying the planting of cuttings from March to June, September or December caused a gradual reduction in the recorded values, which reached their lowest level with the latest planting date (December). These results are somewhat in agreement with those obtained on rooting percentage, since cuttings taken in September and December gave a lower rooting percentage than cuttings planted in March (the values of rooting percentage were associated with the values of total soluble indoles content in the cuttings in these three batches). On the other hand, although the total soluble indoles content was relatively higher in cuttings taken in June than in cuttings taken in September and December, the rooting percentage of cuttings planted in September and December was higher than those planted in June. This result may be related to the lower total carbohydryates content and C/N ratio in cuttings planted in June, compared to cuttings planted in September and December.

Within each batch, the total soluble indoles contents recorded after planting in the basal part of cuttings were relatively lower, in most cases, than those recorded before planting. This result is in agreement with the findings of **Mohamed (1992)** on pecan and **Abo-El-Ez (1994)** on mango, avocado, annona and papaya.

c- Total soluble phenols content

The effect of planting dates on the total soluble phenols content at the base of *Beaumontia grandiflora* cuttings (Table 4) was opposite to their effect on the total soluble indoles content. In both seasons, delaying the planting of cuttings from March to June, September or December caused a gradual increase in the recorded values (whether before planting, or after 30 days from planting), which reached their highest level with planting the cuttings at the latest date (December). The above results indicate that the rooting percentage was adversely affected by the total soluble phenols content in the cuttings, since the increase in rooting percentage was associated with a decrease in the total soluble phenols content. Only one exception to this trend was observed in the cuttings planted in June (which had relatively a lower total soluble phenols content than cuttings planted in September or December) which gave lower rooting percentages 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 and December than in cuttings planted in June. These results are in agreement with the findings of **Abo-Hassan *et al* (1994)**, who mentioned that the poorest rooting of *Ficus infectoria* cuttings was associated with the highest levels of total phenols in the basal parts of the cuttings.

Table 4. Effect of planting dates on the total carbohydrates and nitrogen contents, the C/N ratio, and the total soluble indoles and total soluble phenols contents at the base of cuttings (before planting, and after 30 days from planting), as well as the total carbohydrates content in the leaves of *Benaumontia grandiflora* during the 1999/2000 and 2000/2001 seasons

Planting dates	Chemical composition of basal part of cuttings										Total carbohydrates content in leaves (% of dry matter)
	Before planting					30 days after planting					
	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 (% 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 (1999/2000)											
21 March	30.5	2.57	11.9	0.35	0.52	26.9	1.98	13.6	0.37	0.40	11.6
21 June	21.9	2.75	8.0	0.34	0.62	15.1	1.87	8.1	0.29	0.60	11.0
21 September	23.6	2.10	11.2	0.28	0.69	21.6	1.80	12.0	0.27	0.62	9.6
21 December	22.7	2.20	10.3	0.21	0.77	17.9	1.70	10.5	0.12	0.69	8.0
Second season (2000/2001)											
21 March	26.4	1.99	13.3	0.50	0.60	24.1	1.44	16.7	0.35	0.49	10.8
21 June	18.8	2.32	8.1	0.38	0.71	15.9	1.68	9.5	0.34	0.66	9.6
21 September	18.5	1.72	10.8	0.36	0.78	16.9	1.30	13.0	0.30	0.75	7.9
21 December	20.4	2.02	10.1	0.30	0.99	19.1	1.48	12.9	0.28	0.90	7.5

In general, the total soluble phenols content in the basal parts of the cuttings was decreased after 30 days from planting, as compared with the values recorded before planting. This result is in agreement with the results recorded by **Mohamed (1992)** on pecan and **Abo-El-Ez (1994)** on mango, avocado, annona and papaya.

From the results on the chemical composition of the basal parts of cuttings, it is worth mentioning that the increase in rooting percentage was not only associated with the increase in the total soluble indoles content and 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 of the cuttings. These factors indirectly affect root growth and vegetative growth, since the increase in rooting percentage was associated (in most cases) with an increase in the root growth and vegetative growth of the resulting plants. The only exception to this trend was recorded in cuttings planted in June, which gave the lowest rooting percentage (because of their low total carbohydrates content and C/N ratio), but gave the highest root growth, as well as relatively high vegetative growth. The increase in temperature during the summer months may explain the increase in root growth and vegetative growth, as previously discussed (Tables 2 and 3). Thus, it can be concluded 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- Leaf chemical composition

Total carbohydrates content

Planting *Beaumontia grandiflora* cuttings on different dates had a considerable effect on the total carbohydrates content in the leaves of resulting plants (Table, 4). In both seasons, the highest values were recorded when the cuttings were planted at the earliest date (in March). A high carbohydrates content was also detected by **Darwesh (2000)** in leaves of plants formed from cuttings of *Ficus retusa* "Hawaii" planted in March. The recorded values were decreased steadily as the planting date was delayed from March to June, September or December. The relatively high total carbohydrates content of leaves formed on cuttings planted in March may be caused by the promoting effect of warm temperature in spring on photosynthesis. **Devlin and Witham (1986)** mentioned that photosynthesis reaches its highest level at a critical optimum temperature, and it seems that in this study the optimum temperature was reached in spring when maximum photosynthetic activity occured, resulting in the highest carbohydrates content. The same scientists also stated that under natural conditions, practically all water absorption takes place through the root system. Thus, the relatively vigorous root growth on cuttings planted on this date (21st March) causes a high efficiency of water uptake needed for photosynthesis.

Conclusion: From the above results, it can be concluded that planting *Beaumontia grandiflora* cuttings on 21st March gave the best results in terms of rooting percentage, vegetative growth of resulting plants, as well as relatively high root growth. However, it was observed that although cuttings taken in March gave better results than those taken at other times of the year, the rooting percentage of these cuttings (taken in March) was considerably low.

Experiment II: Effect of IBA concentrations on the rooting of *Beaumontia grandiflora* cuttings, and subsequent plant growth

This experiment was aimed at improving the rooting of cuttings taken in March and the subsequent vegetative growth of the resulting plants by treating the cuttings with different IBA concentrations prior to planting.

1- Rooting percentage

The results recorded in the two seasons (Table, 5) show that treating *Beaumontia grandiflora* cuttings with IBA had a considerable effect on the rooting percentage. In both seasons, untreated cuttings had the lowest rooting percentage, while cuttings treated with IBA showed a steady increase in their rooting percentage as the IBA concentration was raised to 1000, 2000 or 3000 ppm. However, a further increase in the IBA concentration to 4000 ppm caused a slight (insignificant) reduction in the rooting percentage (compared to that obtained with IBA at 3000 ppm). Cuttings treated with IBA at 2000 ppm showed a significant increase in the rooting percentage, as compared to the untreated cuttings in both seasons. In the second season, IBA at 3000 ppm significantly increased the rooting percentage of cuttings as compared to 2000 ppm. **Bilgrami *et al* (1980)** attributed the stimulation of root formation and the increase in the rooting percentage of cuttings treated with IBA to the activation of rhizocaline (a growth cofactor present in the plant tissues), as well as the activation of division of cells from which the roots are initiated. Thus, auxin levels have a considerable effect on adventitious rooting of stem cuttings [**Janick (1986)**, and **Taiz and Zeiger (1998)**]. The generally favourable effect of IBA on the rooting of *Beaumontia grandiflora* cuttings is in agreement with the findings of **Bhattacharjee and Balakrishna (1990 and 1991)** on different woody ornamental climbers (including *Hiptage madhablota*, *Ipomoea beraviensis*, *Clerodendrum splendens*, *Ipomoea tuberosa*, *Tecoma jasminoides*, *Thunbergia grandiflora* and *Vernonia elaegnifolia*), as well as **Panwar *et al* (1999), Singh (2001) and Singh (2002)** on *Bougainvillea peruviana* cv. Thimma. In general, the results recorded by these scientists indicated that IBA had a favourable effect on rooting of cuttings when applied at concentrations of 2000-4000 ppm.

2- Root growth

Treatment of *Beaumontia grandiflora* cuttings with IBA had a significant effect on the root growth parameters, viz. root length, number of roots/plant, as well as the fresh and dry weights of roots/plant (Table, 5). In both seasons, cuttings treated with IBA gave significantly higher values for the different root growth characteristics (in most cases), compared to untreated cuttings. The values recorded for all the studied root growth parameters showed a steady increase as the IBA concentration was raised to 1000, 2000 or 3000 ppm. For all the studied root growth parameters,

Table 5. Effect of IBA concentrations on the rooting percentage, root length, number of roots/plant, as well as the fresh and dry weights of roots/plant of *Beaumontia grandiflora* during the 2001 and 2002 seasons

IBA concentrations	*Rooting percentage	Root length (cm)	Number of roots/plant	Fresh weight of roots/plant (g)	Dry weight of roots/plant (g)
First season (2001)					
Control	53.3 c	12.6	3.9	5.81	0.81
1000 ppm	56.7 bc	15.1	5.6	6.30	0.95
2000 ppm	66.7 ab	22.3	8.6	8.47	1.40
3000 ppm	75.0 a	25.3	8.9	9.98	2.14
4000 ppm	71.7 a	19.4	9.5	9.07	1.75
L.S.D. (0.05)	---	1.8	0.3	0.42	0.21
Second season (2002)					
Control	50.0 d	8.5	4.8	6.41	0.74
1000 ppm	60.0 c	13.1	6.0	7.35	1.09
2000 ppm	66.7 bc	17.5	9.8	8.58	1.19
3000 ppm	76.7 a	21.7	11.2	9.49	1.44
4000 ppm	71.7 ab	18.2	12.5	8.16	1.26
L.S.D. (0.05)	---	2.1	0.5	0.56	0.14

* 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.

cuttings treated with IBA at 3000 ppm gave significantly higher values than control cuttings, or cuttings treated with lower IBA concentrations. Similar increases in root growth on cuttings treated with IBA at 2000-5000 ppm have been reported by **Hosni *et al* (2000)** on *Bougainvillea x buttiana* 'Mrs Butt', **Singh (2001)** and **Singh (2002)** on *Bougainvillea peruviana* cv. Thimma.

IBA at the highest level (4000 ppm) caused a significant increase in the number of roots, whereas root length, as well as the fresh and dry weights of roots were significantly decreased, compared to values obtained with IBA at 3000 ppm. The increase in number of roots as a result of raising the IBA concentration is in agreement with the findings of **Devlin and Witham (1986)**, who reported that application of IAA in lanolin paste to the severed end of a young stem stimulates the rate of formation and number of roots initiated. On the other hand, the reduction in the root length as well as root fresh and dry weights which occurred at the highest

IBA concentration (4000 ppm) confirms the conclusion reached by **Taiz and Zeiger (1998)** who mentioned that the optimum auxin concentration for root elongation and growth is lower than that needed for root initiation.

3- Plant vegetative growth

Treatment of the cuttings with IBA had a marked effect on plant vegetative growth (Table, 6). In both seasons, cuttings treated with IBA gave significantly higher values for most of the studied growth characteristics (plant height, number of leaves/plant, as well as the fresh and dry weights of stems and leaves/plant), compared to control cuttings. In general, raising the IBA concentration up to 3000 ppm caused steady significant increases in the values of all the different growth parameters. In most cases, values recorded with IBA at 4000 ppm were insignificantly higher than those recorded with IBA at 3000 ppm. The increase in vegetative growth as a result of IBA treatments is in agreement with the findings of **Panwar *et al* (1999)** on *Bougainvillea peruviana*, **Schoellhorn (2001)** on *Dichorisandra thyrsiflora* and *Cestrum elegans*, **Singh (2001)** on *Bougainvillea peruviana*, **Sharma *et al* (2002, a)** on *Gardenia lucida*, and **Sharma *et al* (2002, b)** on *Acalypha wilkesiana* cv. Tahiti, who reported that IBA at concentrations of 1000-5000 ppm improved plant vegetative growth. The favourable effect of IBA treatments on plant vegetative growth may be attributed to the enhancement of rooting percentage and root system growth on treated cuttings (especially in terms of number of roots), which leads to an increase in the uptake of water and nutrients from the growing medium (**Devlin and Witham, 1986**), resulting in an increase in vegetative growth. Also, some growth characteristics are promoted when certain growth factors (called calines) present in the plant tissues are activated by auxins. For example, stem elongation is promoted by the combination of auxin and caulocaline (**Bilgrami *et al* 1980**).

4- Chemical composition at base of cuttings

a- Total carbohydrates content, total N content and the C/N ratio

The data recorded in the two seasons (Table, 7) show that after 30 days from planting, the content of total carbohydrates at the base of *Beaumontia grandiflora* cuttings treated with IBA was higher than the values determined at the same time in control cuttings. These results are in harmony with those reported by **Singh (1985)** on *Pyrostegia venusta*, **Mitra and Bose (1991)** on litchi cuttings, and **El-Boraie (1998)** on *Jasminum sambac* and *Gardenia jasminoides*. In contrast, untreated cuttings had higher total N contents at the base of cuttings after planting than cuttings receiving the different IBA treatments. As a result of the above observations, the C/N ratio at the base of cuttings after planting was lower in untreated cuttings than in cuttings dipped in the different IBA concentrations.

The relatively high total carbohydrates content in the basal parts of cuttings after planting found in cuttings receiving IBA treatments (which showed improved rootability), combined with a low total nitrogen content, are in agreement with those obtained by **YongKweon and KiSun (1996, b)** on white forsythia

Table 6. Effect of IBA concentrations on plant height, fresh and dry weights of stems/plant, number of leaves/plant, as well as the fresh and dry weights of leaves/plant of *Beaumontia grandiflora* during the 2001 and 2002 seasons

IBA concentrations	Plant height (cm)	Fresh weight of stems /plant (g)	Dry weight of stems /plant (g)	Number of leaves /plant	Fresh weight of leaves /plant (g)	Dry weight of leaves /plant (g)
			First season (2001)			
Control	18.5	10.02	2.83	6.5	3.5	0.57
1000 ppm	20.7	12.74	3.03	6.8	4.5	0.68
2000 ppm	21.7	14.83	4.12	7.6	5.5	0.79
3000 ppm	22.9	17.90	4.64	8.1	6.0	0.85
4000 ppm	24.8	18.40	4.69	8.4	6.2	0.99
L.S.D. (0.05)	0.9	0.62	0.16	0.4	0.3	0.04
			Second season (2002)			
Control	16.4	10.55	2.87	4.6	4.1	0.65
1000 ppm	20.4	11.02	3.19	5.3	4.3	0.73
2000 ppm	24.2	12.34	3.29	6.5	4.9	0.79
3000 ppm	26.2	13.40	4.00	7.1	5.5	1.00
4000 ppm	27.0	16.00	4.17	7.1	5.9	1.04
L.S.D. (0.05)	0.6	0.41	0.25	0.5	0.5	0.06

cuttings which rooted well. Also, the relatively high C/N ratio in cuttings treated with IBA may explain the high rooting percentage and root growth of these cuttings, compared to untreated cuttings, as proposed by **Rana and Chadha (1989)** on *Prunus* species and **El-Boraie (1998)** on *Gardenia jasminoides*.

Generally, no appreciable trend was noted for the total carbohydrates content, total N content, and the C/N ratio in the basal part of cuttings 30 days after planting, in response to raising the IBA concentrations from 1000 to 4000 ppm. Moreover, it could be stated that the C/N ratio in the basal part of stem cuttings 30 days after planting showed no apparent logical relationship to rooting percentage and root growth. A similar results was reported by **El-Boraie (1998)** on *Jasminum sambac*.

The total carbohydrates and total N contents in the basal parts of the cuttings 30 days after planting were lower than in cuttings before planting, regardless of IBA concentration. In contrast, the C/N ratio in the cuttings before planting was lower than in the basal parts of cuttings 30 days after planting, regardless of IBA concentration.

Table 7. Effect of IBA concentrations on the total carbohydrates and total nitrogen contents, C/N ratio, total soluble indoles and total soluble phenols contents at the base of cuttings (after 30 days from planting), as well as the total carbohydrates content in the leaves of *Beaumontia grandiflora* during the 2001 and 2002 seasons

IBA concentration	Chemical composition of basal part of cuttings					Total carbohydrates content in leaves (% of dry matter)
	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 (2001)						
*Before planting	28.9	2.33	12.4	0.54	0.85	
After planting:						
Control	25.0	1.98	12.6	0.34	0.82	10.0
1000 ppm	26.9	1.96	13.7	0.48	0.76	10.7
2000 ppm	25.3	1.87	13.5	0.52	0.78	12.4
3000 ppm	26.8	1.84	14.6	0.58	0.67	13.5
4000 ppm	26.5	1.91	13.9	0.60	0.68	13.8
Second season (2002)						
*Before planting	25.2	2.25	11.2	0.52	0.75	
After planting:						
Control	23.2	2.03	11.4	0.30	0.63	9.1
1000 ppm	23.9	1.88	12.7	0.38	0.50	10.3
2000 ppm	24.7	1.55	15.9	0.42	0.54	10.9
3000 ppm	24.8	1.81	13.7	0.44	0.54	11.4
4000 ppm	24.7	1.75	14.1	0.48	0.57	13.5

* The values recorded prior to planting were determined before treatment with IBA.

b- Total soluble indoles content

The data in Table (7) show that treatment of *Beaumontia grandiflora* cuttings with IBA increased the total soluble indoles content in the basal parts of cuttings 30 days after planting, compared to that recorded at the same time in untreated cuttings. In both seasons, control cuttings gave the lowest values after planting, whereas raising the IBA concentration from 0 (control) to 1000, 2000, 3000 or 4000 ppm caused a gradual increase in the content of total soluble indoles. Similar results were reported by **Zagzog (1995)**, who found that treatment of Le-Cont pear and Romi grape cuttings with IBA at concentrations of 1000, 3000 or 5000 ppm increased their total soluble indoles content after one month from planting, compared to untreated cuttings after the same period.

From the data in Tables (5) and (7) it can be seen that in general, cuttings which had a high total soluble indoles content also had a high rooting percentage and a high number of roots. This observation is in agreement with the conclusion reached by **YongKweon and KiSun (1996, b)** who stated that forsythia (*Abeliophyllum distichum*) cuttings which rooted well had relatively high contents of endogenous IAA. Also, **Hosni *et al* (2000)** reported that dipping *Bougainvillea x buttiana* 'Mrs Butt' cuttings in IBA at 5000 ppm increased their total soluble indoles content and boosted the number of roots formed, possibly as a result of the increase in the total indoles content.

Generally, the total soluble indoles content was higher in the cuttings before planting than in basal parts of the cuttings 30 days after planting, regardless of IBA concentration.

c- Total soluble phenols content

The data presented in Table (7) show that the total soluble phenols content in the basal part of cuttings after 30 days from planting was lower than before planting. The total soluble phenols content at the base of *Beaumontia grandiflora* cuttings was considerably affected by the IBA treatments. In both seasons, cuttings treated with IBA gave lower values 30 days after planting than control cuttings. The decrease in total soluble phenols content as a result of IBA treatments is similar to that detected by **Zagzog (1995)** on Le-Cont pear and Romi grape cuttings.

5- Leaf chemical composition

Total carbohydrates content

Dipping *Beaumontia grandiflora* cuttings in an IBA solution prior to planting had a marked effect on the total carbohydrates content in the leaves of resulting plants (Table 7). In both seasons, control cuttings gave the lowest values. Moreover, raising the IBA concentration in the dipping solution caused a steady increase in the total carbohydrates content, which reached its highest level when the highest IBA concentration (4000 ppm) was used. The enhancement of the synthesis and accumulation of carbohydrates in the leaves of resulting plants following treatment of the cuttings with IBA confirms the results recorded by **Darwesh (2000)** on *Ficus retusa* "Hawaii", who reported that the total carbohydrates content in the leaves was increased steadily by raising the IBA concentration up to 2000 ppm. This increase in the total carbohydrates content of plants formed from cuttings treated with IBA may be an indirect effect resulting from the stimulation of vegetative growth by IBA, which causes an increase in the photosynthetic rate and, consequently, in the synthesis and accumulation of carbohydrates in the tissues.

Conclusion: From the results of the second experiment, it could be concluded that rooting of *Beaumontia grandiflora* semihardwood cuttings taken in March and the subsequent vegetative growth of the resulting plants were improved by IBA treatments, especially at 3000 ppm.

Recommendations

- From the results of the first experiment, it can be recommended that for the best rooting and most vigorous vegetative growth of *Beaumontia grandiflora*, cuttings should be planted at the beginning of spring (on 21st March).
- From the results of the second experiment, it can be recommended that *Beaumontia grandiflora* cuttings should be dipped in an IBA solution at 3000 ppm prior to planting in March.

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مجلة اتحاد الجامعات العربية للدراسات والبحوث الزراعية ، جامعة عين شمس ، القاهرة ، ١١(٢) ، ٧٦٥ - ٧٨٧ ، ٢٠٠٣

تأثير مواعيد الزراعة و إندول حمض البيوتريك على تجذير عقل البومونتيا *Beaumontia grandiflora* Wallich. ونمو النباتات الناتجة

[٥٥]

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أجرى هذا البحث فى صوبة زجاجية بمشتل التجارب بقسم بساتين الزينة، كلية الزراعة، جامعة القاهرة. و إشتملت الدراسة على تجربتين.

أجريت التجربة الأولى خلال الموسمين المتتاليين ١٩٩٩/٢٠٠٠ و ٢٠٠٠/٢٠٠١ بهدف دراسة تأثير مواعيد الزراعة المختلفة على تجذير عقل البومونتيا (*Beaumontia grandiflora* Wallich.) وكذلك النمو و التركيب الكيماوى للنباتات الناتجة. فقد تم زراعة عقل ساقية نصف خشبية (بطول ١٥ سم، مزال أوراقها، ذات ٣ عقد) فى ٢١ مارس، ٢١ يونيو، ٢١ سبتمبر، ٢١ ديسمبر.

وأظهرت النتائج المسجلة بعد أربعة أشهر من الزراعة الآتى:

- زراعة العقل فى مارس أعطت أعلى نسبة مئوية للتجذير، و أفضل نمو خضرى للنباتات الناتجة (من حيث إرتفاع النبات، و عدد الأوراق، و كذلك الأوزان الطازجة و الجافة للأوراق والسيقان لكل نبات). و تم تسجيل أعلى محتوى من الكربوهيدرات الكلية ، ونسبة الكربون إلى النتروجين (C/N ratio)، و الإندولات الذائبة الكلية ، وكذلك أقل محتوى من الفينولات الذائبة الكلية فى العقل المنزرعة فى مارس سواء قبل الزراعة أو فى الأجزاء القاعدية من العقل بعد ٣٠ يوم من الزراعة. بالإضافة إلى ذلك فإن أوراق النباتات الناتجة من عقل منزرعة فى مارس كانت ذات أعلى محتوى من الكربوهيدرات الكلية مقارنة بالنباتات الناتجة من عقل منزرعة فى المواعيد الأخرى.
- الزراعة فى مارس أو يونيو أعطت أفضل نمو للجذور من حيث طول الجذر، عدد الجذور/نبات، و الأوزان الطازجة و الجافة للجذور/نبات.
- وجدت علاقة إيجابية بين التغيرات الموسمية فى نسبة الكربون إلى النتروجين (C/N ratio) والنسبة المئوية لتجذير العقل، أى أن مواعيد الزراعة التى كانت عندها نسبة C/N فى العقل

مرتفعة أعطت نسبة منوية مرتفعة للتجذير.

أجريت التجربة الثانية خلال الموسمين المتتاليين ٢٠٠١ و ٢٠٠٢ بهدف دراسة إمكانية إستخدام إندول حمض البيوتريك (IBA) لتحسين تجذير العقل المنزرعة في مارس، و كذلك النمو الخضرى والتركيب الكيماوى للنباتات الناتجة. وقد غمست قواعد العقل المأخوذة في مارس في محلول IBA بتركيزات صفر (كنترول)، ١٠٠٠، ٢٠٠٠، ٣٠٠٠ و ٤٠٠٠ جزء في المليون لمدة ١٠ ثواني قبل الزراعة.

وأظهرت النتائج المسجلة بعد أربعة أشهر من الزراعة ما يلي:

- استخدام IBA بتركيز ٣٠٠٠ جزء في المليون أعطى أعلى نسبة مئوية للتجذير. كذلك أدى رفع تركيز IBA حتى ٣٠٠٠ جزء في المليون إلى زيادة معنوية في معظم صفات نمو الجذور و صفات النمو الخضرى.
- إستخدام IBA بتركيز ٣٠٠٠ أو ٤٠٠٠ جزء في المليون أعطى أعلى محتوى من الإندولات الذائبة الكلية في قواعد العقل بعد الزراعة، و أعلى محتوى من الكربوهيدرات الكلية في أوراق النباتات الناتجة.
- لم تتم ملاحظة علاقة منطقية بين نسبة الـ C/N في قواعد العقل بعد الزراعة وزيادة نسبة التجذير الناتجة عند زيادة تركيزات الـ IBA حتى ٣٠٠٠ جزء في المليون.

من النتائج السابقة، يمكن التوصية بغمس عقل البومونتيا (*Beaumontia grandiflora*) في محلول IBA بتركيز ٣٠٠٠ جزء في المليون قبل زراعتها في مارس و ذلك للحصول على أفضل تجذير للعقل و أقوى نمو خضرى للنباتات الناتجة.

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