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Successful Propagation of Magnolia (*Magnolia grandiflora* cv. Gallisoniensis) by Two Budding Techniques for Nursery Tree Production

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Abstract

With its large fragrant white flowers and evergreen leaves, *Magnolia grandiflora* is one of a very popular ornamental plants grown worldwide. It is also among the valuable plant species preferred for urban and forest ecosystems. This study aimed to determine effects of two budding techniques and dates on budding success of *Magnolia grandiflora* cv. Gallisoniensis. In spring 2021, patch budding on seven different dates and chip budding on three different dates were performed under high plastic tunnel conditions. In summer 2021, patch budding was carried out under open field conditions on three different dates. Small buds (SB) and large buds (LB) of scions were used for spring and summer patch budding. The patch and chip budding success were significantly ($p<0.05$) affected by budding dates. Patch budding success, which ranged from 76% to 100% in the spring, was 100% with SB on May 24, and SB and LB on May 30. The success of spring chip budding varied between 88% and 92%. Tree growth seasons after budding, the average plant height development of patch and chip buddings under nursery conditions reached 186 cm and 177 cm, respectively. In addition, 30% of all budded plants bloomed in 2022 and 70% in 2023.

Keywords: Magnolia; *Magnolia grandiflora* cv. Gallisoniensis; Chip budding; Patch budding; propagation

Abbreviations: MT: Mean Temperature; MMaxT: Mean Maximum Temperature; MMinT: Mean Minimum Temperature; SD: Sunshine Duration; TP: Total Precipitation. SB: Small Bud; LB: Large Bud; MS: Measurement recorded just above the plant's soil level; NS: Non-significance

Introduction

Magnolias, which are included in the *Magnoliaceae* family, Magnolia genus, grow in the form of deciduous and evergreen trees or large shrubs [1] and have over 250 species [2]. Magnolia species are widely distributed in temperate and tropical Southeast and East Asia [3]. Magnolias are woody perennial outdoor ornamental plants that have high landscape value both aesthetically and functionally and are widely used in large areas for different purposes in many countries [4-6]. They are in the class of valuable and expensive plants in nurseries [7].

Southern magnolia (*Magnolia grandiflora*), also called evergreen magnolia, has large fragrant white flowers and evergreen leaves, making it both one of the most magnificent of forest trees and a very popular ornamental plant grown worldwide [8,9]. It is one of the popular plants of urban and forest ecosystems and performs well in urban conditions. It is used as a screen or fence in urban and suburban areas and is resistant to sulfur dioxide damage [9]. *Magnolia grandiflora* exhibits a successful development and performance in street environments in Europe and North America [10]. It is one of the most common evergreen tree species in subtropical area in China [11]. In forest ecosystems in the temperate region, which consists of a complex species composition, magnolia is among the less common species, along with tree species belonging to various genera such as *Alnus, Betula, Carya, Castanea, Juglans, Liriodendron* and *Phellodendron* [12]. The southern magnolia is commercially important as a source of wood for manufactured products, and its wood is utilized in two major material classes, lumber, and veneer [13]. It has a high commercial value as both a timber species and as a popular nursery tree.

Magnolia grandiflora was brought to Europe from America in the 1730s and has been widely used in Anatolia since the beginning of the 19th century. It is well adapted to the ecological conditions of the Black Sea, Mediterranean, Marmara and Aegean regions and has become one of the most popular plants in old Turkish mansion and palace gardens [14,15]. The main character of *Magnolia grandiflora* trees is large, lemony frangrance, creamy-white, and waxy showy flowers.

On the other hand, drought tolerance is becoming an increasingly important criterion for the selection of tree species, especially in urban ecosystems where water availability is low, and *Magnolia grandiflora* is therefore considered a promising alternative to *Magnolia soulangeana* for these areas under projected climate change scenarios [16]. In addition, southern magnolia has been reported as a storm-resistant tree in urban areas, parks, and yards and as an alternative to *Pyrus calleryana* and red (*Acer rubrum*) and silver (*Acer saccharinum*) maples [17].

Most scientific information on magnolias focuses on various plant characteristics of the species, such as aesthetic characteristics such as flowers, leaf textures, autumn colors and height [10]. Scientific resources regarding their graft propagation are limited. Magnolias can be propagated by generative [18] and vegetative (cutting, grafting, layering and tissue culture) methods [19-21]. Although seed propagation provides a more intensive production opportunity compared to other propagation methods [22], its success level is low. *Magnolia grandiflora* cultivars are difficult to propagate from stem cutting in large numbers on a consistent basis [23]. Vegetative methods are mostly used for their propagation [24].

Grafting promotes earlier flowering of magnolia plants, compared to seedlings, grafted magnolia plants (*Magnolia liliflora* Desr.) can shorten the flowering onset time by more than 10 years, and the first flowers of the grafted plant are larger than those of the ungrafted one [25]. Therefore, propagation of magnolia by grafting maintains its importance [26]. Magnolias can be propagated by various grafting methods in the United States [27-29], England [30], New Zealand [31], south Korea [32], and China [25, 33, 34]. Although successful results have been reported from many grafting and budding techniques such as chip budding and cover grafting for magnolias [29, 35, 36], scientific resources on graft propagation are limited.

Many factors, such as the condition of rootstock and scion, whether rootstocks are open-rooted or tubed/potted, medium materials, timing, method, skill of the grafter, propagation systems, environmental conditions during and after grafting, care of the grafted plants, and transplanting conditions can affect the success of magnolia. Temperature and relative humidity values during and after the grafting period impact successful graft union and the graft survival in many woody species [37-41]. In addition, grafting time and kinds of rootstock are the major factors that influences the success [42]. There is no scientific reports on the propagation of magnolia by grafting in Turkish literature. The aim of this study is to propagate magnolia (*Magnolia grandiflora* cv. Gallisoniensis), an urban plant, using patch budding and chip budding techniques, to determine appropriate seasonal budding times and to evaluate the development of budded plants under nursery conditions.

Material and Methods

Study area

The research areas were Ünye district of Ordu province located in the Central Black Sea region and Sakarya province located in Marmara region of Turkey. Budding studies were carried out in Ünye district and data on the success of budded plants were recorded there. Afterwards, the plants budded in spring were transferred in tubes to Sakarya province and left to develop under nursery conditions there.

The district Ünye is situated between 41° 07’ 11’’ north latitudes and 37° 16’ 48’ east longitudes. Ünye is a coastal district at sea level. Its soil structure is composed of alluvial, chestnut and brown forest soils. The climate of Ünye district shows the typical Black Sea climate. According to long-term (1959-2022) average climate data in Ordu province, the annual average temperature is 14.5 °C and the annual precipitation is 1049 mm. Mean temperatures from April to September are 11.4 °C in April, 15.7 °C in May, 20.4 °C in June, 23.2 °C in July, 23.5 °C in August and 20.3 °C in September, respectively (Table 1). The ranges of daily minimum, maximum and mean temperature and relative humidity during budding periods and the following months are shown in Figure 1 and Figure 2 [43].

The district Arifiye is located between 40° 43’ 16’’ north latitudes and 30° 22’ 12’ east longitudes. It is located to the east of Sapanca Lake. Its altitude is 40 m. The climate of the district exhibits the typical Marmara region climate. Arifiye, with its forested areas, is a district with green nature. It has fertile soil and very rich flora. There are many broad-leaved and coniferous forest tree species in the rich flora of the district. According to long-term (1951-2022) average climate data in Sakarya province, the annual average temperature is 14.6 °C and the annual precipitation is 843 mm, and the coldest month of the year is January with the average of 6.1 °C. Mean temperatures from April to September are 12.9 °C in April, 17.4 °C in May, 21.4 °C in June, 23.4 °C in July, 23.4 °C in August and 19.8 °C in September, respectively (Table 2).

Plant Materials

The rootstock material in the study was two-year-old seedlings of magnolia (*Magnolia grandiflora* L.). Scions were collected from annual shoots of magnolia (*Magnolia grandiflora* cv. Gallisoniensis) trees grown in Ünye district, Ordu province, Türkiye. The scions were taken fresh on the morning of the budding day, and were kept in a damp cloth during the day to prevent moisture loss until budding.

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Figure 1: Change of daily minimum, maximum and mean temperatures in April-June and August-October of the budding year (2021) in the study area (Ünye district of Ordu province) where magnolia plants were budded [44].

Patch Budding and Chip Budding in Spring

Magnolia (*Magnolia grandiflora* L.) seedlings were placed in 2.5 lt black plastic tubes in November 2020 and kept in an unheated high plastic tunnel (length 56 m, width 9 m and height 3.5 m) established at zero altitude until budding. They were regularly watered in the morning and evening every day to remove the bark on the stem easily from about 2 weeks before budding. Seedlings were pruned leaving 3-4 leaves on their tops and made ready for budding. The mixture of burnt animal manure, soil, peat, and mushroom compost (1:1:1:1) was used as the medium in the tubes. In 2021, patch budding on seven different dates (April 19, April 26, May 3, May 17, May 24, and May 30) and chip budding on 3 different dates were (April 19, April 26, and May 3) done on magnolia seedling rootstocks under high plastic tunnel conditions. For patch buddings, two different bud sizes (large buds of 3-6 mm and smaller buds than 3 mm) were used.

The large buds were prepared from the middle-upper part of the scions, and small buds were taken from the middle-lower part of the scions. The first two buds from the bottom of the annual shoots were not used for budding. For chip budding, approximately 4-5 mm buds taken from the middle parts of the annual shoots were used. Patch buddings and chip buddings (Figure 3) were made directly on the seedling in the plastic tube. They were applied at a height of 10-15 cm from the soil level of the seedling stems. Silicone bands were used to wrap the buddings. The bands were removed 6 weeks after budding. The high plastic tunnel was regularly ventilated, and the budded plants were carefully cared for. Budded plants were kept in high plastic tunnel until September. Successful patch and chip buddings (Figure 4) were transferred to the field conditions in plastic tubes. They were then transported to from Ünye district to Sakarya province in late autumn of 2021, where they were planted in nursery conditions and allowed to develop.

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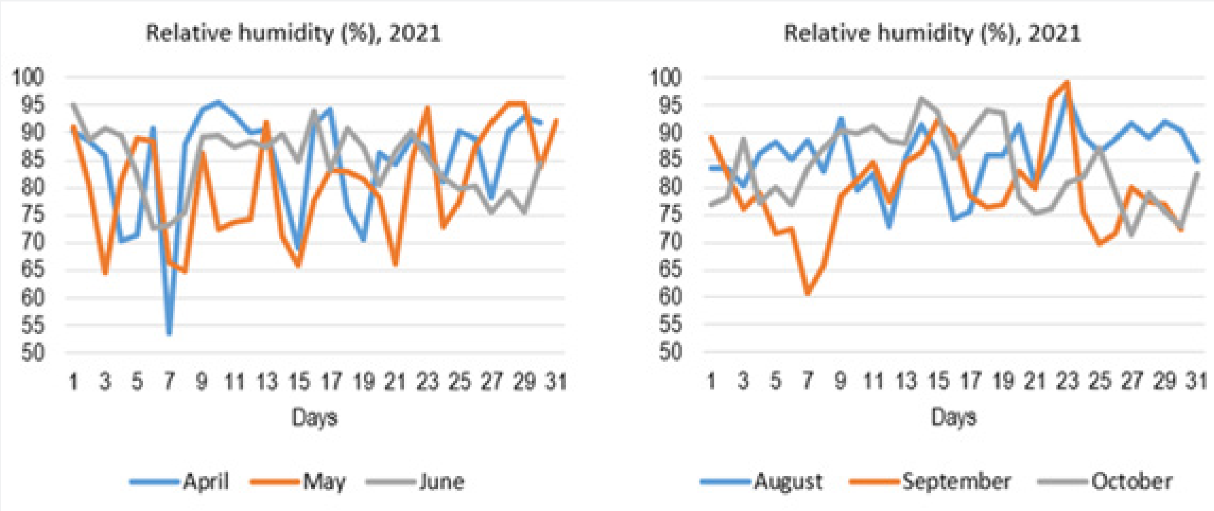

Figure 2: Change of daily humidity in April-June and August-October of the budding year (2021) in the study area (Ünye district of Ordu province) where magnolia plants were budded [44].

Figure 3: Magnolia (Magnolia grandiflora cv. Gallisoniensis) patch budding (left) and chip budding (right).

Patch Budding in Summer

Magnolia (*Magnolia grandiflora* L.) seedlings were placed in 2.5 lt large black pots in November 2020 and kept in an unheated high plastic tunnel until May 2021. Potted seedlings were transferred to outdoor conditions in mid-May and developed until budding. They were regularly watered in the morning and evening every day to remove the bark on the stem easily from about 2 weeks before budding. Seedlings were pruned leaving 3-4 leaves on their tops and made ready for budding. The mixture of burnt animal manure, soil, peat, and mushroom compost (1:1:1:1) was used as the medium in the pots. In 2021, patch buddings were made on magnolia seedling rootstocks in open field conditions on three different dates (22 August, 29 August, and 5 September). For patch buddings, two different bud sizes (buds of 3-6 mm and smaller buds than 3 mm) and two different rootstock thickness (pencil thickness and thicker than pencil) were tried. The large buds were prepared from the middle-upper part of the scions, and small buds were taken from the middle-lower part of the scions. The first two buds from the bottom of the annual shoots were not

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used for budding. Patch buddings were done directly on the potted seedlings. They were applied at a height of 10-15 cm from the soil level of the seedling stems. Silicone bands were used to wrap the buddings. The bands were removed 6 weeks after budding. Patch budded plants were placed in a high plastic tunnel for protection from the cold in the first week of November 2021, and transferred to open field conditions for development in late April 2022. They were carefully cared for.

Figure 4: Successful magnolia (Magnolia grandiflora cv. Gallisoniensis) plants after spring budding.

Table 1: Long-term (1959-2022) average climate data of Ordu province [43].

	Months												Yearly
	1	2	3	4	5	6	7	8	9	10	11	12	
MT (°C)	7	7	8.2	11.4	15.7	20.4	23.2	23.5	20.3	16.2	12.2	9	x̄ 14.5
MMinT (°C)	4	4	5.2	8.3	12.5	16.7	19.6	20.1	16.9	13.1	8.9	6	x̄ 11.3
MMaxT (°C)	10.9	11.1	12.2	15.3	19.3	24.1	26.8	27.4	24.4	20.2	16.5	13.1	x̄ 18.4
SD (h)	2.5	3.1	3.4	4.4	5.6	6.9	6.3	6.1	5.2	4.1	3.4	2.5	x̄ 4.5
TP (mm)	103.9	83.3	82.6	66.5	56.7	70.6	64.9	70.3	84.3	131.2	121.1	113.7	Σ 1049

MT: Mean Temperature; MMaxT: Mean Maximum Temperature; MMinT: Mean Minimum Temperature; SD: Sunshine Duration; TP: Total Precipitation.

Table 2: Long-term (1951-2022) average climate data of Sakarya province [43].

	Months												Yearly
	1	2	3	4	5	6	7	8	9	10	11	12	
MT (°C)	6.1	6.8	8.7	12.9	17.4	21.4	23.4	23.4	19.8	15.6	11.7	8.3	x̄ 14.6
MMinT (°C)	3	3.4	4.6	8.1	12.3	15.9	18	18.1	14.5	11.1	7.6	5.1	x̄ 10.1
MMaxT (°C)	9.9	11.2	13.8	19	23.6	27.6	29.4	29.5	26.4	21.4	16.9	12	x̄ 20.1
SD (h)	2.5	3.2	4	5.3	6.6	8.1	8.9	8.5	6.9	4.7	3.5	2.5	x̄ 5.4
TP (mm)	94.3	76.2	75.1	58.9	53.3	73.5	49.7	49.6	52.1	78.3	74.9	107	Σ 843

MT: Mean Temperature; MMaxT: Mean Maximum Temperature; MMinT: Mean Minimum Temperature; SD: Sunshine Duration; TP: Total Precipitation.

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Table 3: Data on budding success (%), shooting (%), shoot length (cm), shoot diameter (mm), rootstock diameter (mm), height of budded plant (cm) and number of leaves on shoot for spring patch buddings of magnolia (*Magnolia grandiflora* cv. Gallisoniensis) as of 27 September 2021.

Patch budding date (2021)	Bud size	Budding success (%)	Shooting (%)	Shoot length (cm)	Shoot diameter (mm)	Rootstock diameter (mm)^{MS}	Height of budded plant (cm)	Number of leaves on shoot
19-Apr	SB	88 bc	86.3 d	8.6 g	5.1 d	12.6 bcd	20.3 cde	7.0 b-e
	LB	84 cd	90.4 c	13.2 b	6.8 a	14.2 a	26.4 a	8.2 a
26-Apr	SB	88 bc	90.9 c	11.1 def	6.7 ab	13.4 ab	19.5 ef	7.3 b-e
	LB	84 cd	85.7 d	11.5 b-f	5.1 d	12.4 b-e	19.9 def	7.7 ab
3-May	SB	80 de	95.0 b	10.2 fg	5.7 bcd	12.1 b-f	17.6 f	5.8 f
	LB	80 de	90.0 c	12.9 bc	6.5 ab	13.1 abc	23.1 b	7.6 abc
10-May	SB	76 e	89.4 c	11.3 c-f	6.0 a-d	11.4 d-g	19.9 def	7.3 bcd
	LB	84 cd	95.2 b	15.8 a	6.6 ab	12.8 a-d	27.0 a	8.3 a
17-May	SB	84 cd	85.7 d	12.1 b-e	5.3 cd	10.6 g	22.1 bcd	6.9 cde
	LB	84 cd	90.4 c	12.1 b-e	6.2 abc	13.0 abc	22.6 bc	6.5 ef
24-May	SB	92 b	91.3 c	9.9 fg	5.3 cd	10.8 fg	18.7 ef	6.6 de
	LB	100 a	96.0 b	13.3 b	6.1 abc	13.4 ab	23.8 b	8.2 a
30-May	SB	100 a	100 a	10.9 ef	6.0 a-d	11.1 efg	19.7 def	7.2 b-e
	LB	100 a	92.0 c	12.9 bcd	5.8 bcd	11.7 c-g	19.0 ef	7.2 b-e
Mean		87.4	91.5	11.8	5.9	12.3	21.4	7.3
Significance		***	***	***	***	***	***	***
LSD (0.05)		7.5	3.06	1.78	0.97	1.47	2.46	0.74

SB: Small Bud; LB: Large Bud; MS: Measurement recorded just above the plant's soil level.

Development of Budded Plants Under Nursery conditions

Successful magnolia plants budded in spring 2021 were transported to Sakarya province (Marmara region, Türkiye) in late autumn 2021. There they were left to develop under nursery conditions. Their planting spacing was 2.2 x 1.5 m. Plant height and stem diameter developments of budded plants were recorded at the end of October 2023. Additionally, flowering percentages in 2022 and 2023 were also determined collectively.

Study Data

Budding data were taken on 27 September 2021 for spring patch buddings and chip buddings (about 4-5 months after budding) and 15 June 2022 for summer patch buddings (about 10 months after budding). On these dates, data on budding success (%), shoot length and diameter of budded plant (cm), rootstock diameter (mm) and height of budded plant were recorded. The budding success expressed the survival rates of the budded plants. Rootstock diameter (mm) was determined by measuring the stem thickness just above the soil level of the plant. Shoot diameter of budded plant was measured just above the graft union.

Statistical Analysis

The study was performed according to a completely randomized design with five replicates (five plants per replicate). The data were analyzed with one-way analysis of variance (ANOVA) using the statistical package programs JMP 14.0 and Minitab 17. Statistical differences between the mean values were determined at the 5% significance level by the LSD multiple comparison method. The study was carried out with a total of 725 buddings. The number of budded magnolia plant was 350 for spring patch budding and 75 for spring chip budding, and 300 for summer patch budding.

Results

Spring Patch Budding

The success, shooting, shoot length, shoot diameter, rootstock diameter, height of budded plant and number of leaves on shoot for spring patch budding differed significantly ($p<0.05$). The success varied between 76% and 100% depending on budding dates. It was 100% for patch buddings dated April 4 (with SB) and dated May 30 (with SB and LB). Shooting ranging from 85.7% to 100% was 100% for patch buddings dated May 30 using SB. Shoot length was measured between 8.6 cm and 13.3 cm. Shoot diameter was between 5.1 mm and 6.8 mm. Rootstock diameter varied between 10.6 mm to 14.2 mm. The height of budded plant was between 17.6 cm and 26.4 cm. The number of leaves on shoot changed between 5.8 and 8.3 (Table 3).

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On the other hand, the comparative results of the data on spring patch buddings based on bud size are given in Table 4. The budding success and shooting rates of SB and LB applications were statistically indifferent (p<0.05). Significant differences (p<0.05) were computed between SB and LB applications in terms of shoot length and diameter, rootstock diameter, height of budded plant and number of leaves on shoot (Table 4).

Spring Chip Budding

Success rates ranging from 88% to 92% for spring chip budding were statistically indifferent (p<0.05). Shooting, shoot length, rootstock diameter, height of budded plant and number of leaves on shoot differed significantly (p<0.05). Shooting rate was 100% for patch buddings dated April 19 and April 26. Shoot length was between 11.1 cm and 16.5 cm. Shoot diameter was measured between 5.7 mm and 7.6 mm. Rootstock diameter changed between 13.6 mm to 15.5 mm. The height of budded plant was determined between 20.8 cm and 28.4 cm. The number of leaves on shoot varied between 7.5 and 8.9 (Table 5).

Summer Patch Budding

The success rates ranging from 80% to 92% for summer patch budding were statistically indifferent (p<0.05). Shooting, shoot length, shoot diameter, rootstock diameter, height of budded plant and number of leaves on shoot differed significantly (p<0.05). Shooting varied between 76.1% and 90.9% depending on rootstock thickness and bud size. Shoot length was between 13.1 cm and 19.8 cm. Shoot diameter was measured between 6.0 mm and 10.5 mm. Rootstock diameter changed between 6.3 mm to 13.9 mm. The height of budded plant was determined between 20.3 cm and 29.4 cm. The number of leaves on shoot was between 6.2 and 9.1 (Table 6).

On the other hand, the comparative results of the data on summer patch buddings based on bud size are presented in Table 7. Using SB and LB, values of budding success, shoot length, rootstock diameter and number of leaves on shoot were statistically indifferent (p<0.05). When LB was uesd, values of shooting, shoot diameter, rootstock diameter and height of budded plant were higher than those of SB. In addition, the comparative results of the data on summer patch buddings based on rootstock thickness are given in Table 8. Using thin and thick rootstocks, values of budding success, shooting and height of budded plant were statistically indifferent (p<0.05). When thick rootstocks were used, values of shoot length, rootstock diameter, rootstock diameter and number of leaves on shoot were found higher than those of thin rootstocks.

Table 4: Bud size-based comparison of spring patch buddings of magnolia (*Magnolia grandiflora* cv. Gallisoniensis).

	SB	LB	Significance	LSD (0.05)
Budding success (%)	86.8	88	NS	4.95
Shooting (%)	91.4	91.3	NS	2.23
Shoot length (cm)	10.6 b	13.1 a	***	0.7
Shoot diameter (mm)	5.7 b	6.1 a	*	0.38
Rootstock diameter (mm)	11.7 b	12.9 a	***	0.57
Height of budded plant (cm)	19.7 b	23.1 a	***	1.02
Number of leaves on shoot	6.9 b	7.7 a	***	0.3

NS: Non-significance; SB: Small Bud; LB: Large Bud.

Table 5: Data on budding success (%), shooting (%), shoot length (cm), shoot diameter (mm), rootstock diameter (mm), height of budded plant (cm) and number of leaves on shoot for spring chip buddings of magnolia (*Magnolia grandiflora* cv. Gallisoniensis) as of 27 September 2021.

Chip budding date (2021)	Budding success (%)	Shooting (%)	Shoot length (cm)	Shoot diameter (mm)	Rootstock diameter (mm)[MS]	Height of budded plant (cm)	Number of leaves on shoot
19-Apr	92	100 a	16.5 a	7.6	15.5 a	28.4 a	8.9 a
26-Apr	96	100 a	13.8 b	6.5	15.2 ab	23.9 b	7.5 b
3-May	88	86.3 b	11.1 c	5.7	13.6 b	20.8 c	7.6 b
Mean	92	95.4	13.8	6.6	14.8	24.4	8
Significance	NS	***	***	NS	*	***	*
LSD (0.05)	14.23	1.94	2.18	1.78	1.64	3.15	1.13

NS: Non-significance; MS: Measurement recorded just above the plant's soil level.

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Table 6: Data on budding success (%), shooting (%), shoot length (cm), shoot diameter (mm), rootstock diameter (mm), height of budded plant (cm) and number of leaves on shoot for summer patch buddings of magnolia (*Magnolia grandiflora* cv. Gallisoniensis) as of 15 June 2022.

Patch budding date (2021)	Rootstock thickness	Bud size	Budding success (%)	Shooting (%)	Shoot length (cm)	Shoot diameter (mm)	Rootstock diameter (mm)[MS]	Height of budded plant (cm)	Number of leaves on shoot
22-Aug	Thin	SB	84	76.1 d	13.1 e	6.0 f	6.3 f	20.8 e	6.2 f
	Thin	LB	88	90.9 a	14.7 c	6.8 de	6.8 ef	26.8 c	6.9 e
	Thick	SB	84	85.7 c	13.4 de	9.2 c	12.2 c	20.3 e	7.0 de
	Thick	LB	88	90.9 a	13.3 de	10.5 a	12.1 c	21.3 e	6.4 f
29-Aug	Thin	SB	84	90.4 a	14.3 cd	5.4 g	6.6 f	23.9 d	6.2 f
	Thin	LB	92	86.9 bc	16.1 b	6.4 ef	7.4 de	27.8 abc	7.9 b
	Thick	SB	88	90.9 a	14.9 c	10.1 ab	13.9 a	25.0 d	6.9 e
	Thick	LB	88	90.9 a	16.1 b	9.7 b	13.1 b	27.3 bc	7.5 bcd
5 Sept	Thin	SB	92	86.9 bc	16.3 b	6.2 f	7.6 d	28.1 abc	7.2 cde
	Thin	LB	80	90.0 ab	16.4 b	7.0 d	7.3 de	28.7 ab	7.1 cde
	Thick	SB	88	86.3 c	19.8 a	9.9 b	13.6 ab	29.4 a	9.1 a
	Thick	LB	88	90.9 a	16.8 b	10.0 ab	13.4 ab	26.9 c	7.6 bc
Mean			87	88.1	15.4	8.1	10	25.5	7.2
Significance			NS	***	***	***	***	***	***
LSD (0.05)			12.72	3.46	0.99	0.52	0.58	1.73	0.54

NS: Non-significance; MS: Measurement recorded just above the plant's soil level.

Table 7: Bud size-based comparison of summer patch budding of Magnolia (*Magnolia grandiflora* cv. Gallisoniensis).

	SB	LB	Significance	LSD (0.05)
Budding success (%)	86.6	87.3	NS	5.01
Shooting (%)	86.3 b	90.1 a	***	1.93
Shoot length (cm)	15.2	15.5	NS	0.58
Shoot diameter (mm)	7.7 b	8.4 a	*	0.47
Rootstock diameter (mm)	10	9.9	NS	0.74
Height of budded plant (cm)	24.6 b	26.4 a	***	0.96
Number of leaves on shoot	7.1	7.2	NS	0.28

NS: Non-significance; SB: Small Bud; LB: Large Bud.

Table 8: Rootstock thickness-based comparison of summer patch budding of magnolia (*Magnolia grandiflora* cv. Gallisoniensis.

	Thin rootstock	Thick rootstock	Significance	LSD (0.05)
Budding success (%)	86.6	87.3	NS	5.01
Shooting (%)	87	89.4	NS	2.07
Shoot length (cm)	15.1 b	15.7 a	*	0.57
Shoot diameter (mm)	6.2 b	9.9 a	***	0.23
Rootstock diameter (mm)	6.9 b	13.0 a	***	0.27
Height of budded plant (cm)	26	25	NS	0.98
Number of leaves on shoot	6.9 b	7.4 a	***	0.27

NS: Non-significance.

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Figure 5: The development of budded magnolia (Magnolia grandiflora cv. Gallisoniensis) plants in nursery conditions.

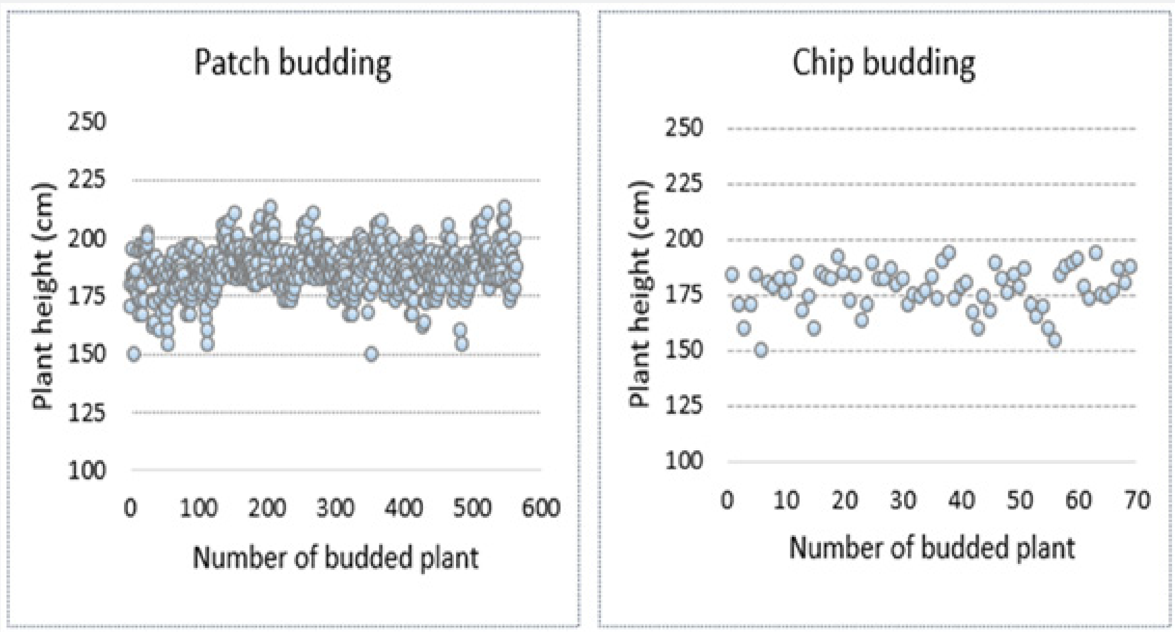

Figure 6: Distribution of plant height in magnolia (Magnolia grandiflora cv. Gallisoniensis) plants patch-budded (left) and chip-budded (right) in spring 2021 as of the end of October 2023.

The Development of Budded Plants in Nursey Conditions

Data on the development of magnolia plants budded in spring 2021 was presented in Table 9. As of late October 2023, the average plant heights of patch and chip buddings in nursery conditions (Figure 5) reached 186 cm and 177 cm, respectively. They differed statistically ($p<0.05$). Plant stem diameters of patch and chip buddings were 3.85 cm and 3.75 cm, respectively, and

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they were not statistically different from each other. Their plant height distributions were exhibited in Figure 6. The blooming percentage of all budded plants was 30% in 2022 and 70% in 2023.

Table 9: Plant height and stem diameter developments of magnolia (*Magnolia grandiflora* cv. Gallisoniensis) plants budded in spring 2021 as of the end of October 2023.

Budding technique	Plant height (cm)	Plant stem diameter (cm)[MS]
Patch budding	186.5 a	3.85
Chip budding	177.4 b	3.75
Significance	**	NS
LSD (0.05)	5.4	0.12

NS: Non-significance; MS: Measured just above the soil level of the plant.

Discussion

Although the success of spring patch budding varied between 76% and 100%, it was 100% for patch buddings dated April 4 (with SB) and dated May 30 (with SB and LB). Budding success was not affected by bud size. Using LB, higher shoot length and number of leaves on shoot were determined. The success rate of spring chip budding ranged from 88% to 92%. But it was not statistically influenced by budding date. Patch buddings dated April 19 and April 26 performed better in terms of development than May 3. In addition, the success of summer patch budding ranged from 80% to 92%, with an average of about 86-87%. It was not statistically affected by budding date, bud size and rootstock thickness.

In the literature, chip budding and veneer grafting for magnolias have been emphasized as a popular and successful propagation method [35,36]. Lodder [27] reported that *Magnolia grandiflora* cultivars were propagated by budding technique in open field conditions using potted or tubed rootstocks in early spring or summer in California. Knuckey [30] obtained successful results ranging from 75% to 95% from magnolia T-budding and chip buddings made from August to October under greenhouse conditions in England. Itaya [35] recorded high success (95%) from magnolia buddings in California in April. In Korea, Lee [32] achieved success ranging from 43% to 89.5% from the grafted *Magnolia grandiflora* plants on *Magnolia kobus* rootstock using veneer graft. He reported that more successful results were obtained with two-year-old rootstocks and well-developed winter buds on one-two-year-old shoots. Hesselein [29] who propagated magnolias by the method of chip budding on *Magnolia kobus* seedling rootstocks in New Jersey (USA) reported that grafting success rarely fell below 90%. Qing'an and Xiaoming [33] noted in their study in China that one-year-old scions of *Magnolia officinalis* gave higher success (2.1 times more) than two-year-olds. Gu et al. [25] who grafted *M. liliflora* onto its one-two-year-old seedlings in February and September months in Beichuan district, China achieved survival rates of 83.3% and 80% for cleft grafting, 0% and 2.9% for tongue grafting, 94.1% and 97% for single-bud side grafting, 67.1% and 87.5% for shoot side grafting and 21.8% and 17.8% for bud slice side grafting in these months, respectively. The researchers, who reported that weak buds on the lower part of shoots are not suitable for grafting, obtained a survival rate of 97.1% with a central full bud in a single bud grafting, 81.6% with terminal bud in shoot side grafting and 87.1% with central full bud in cleft grafting. Ji et al. [34] *Magnolia sinostellata* grafted on *Magnolia denudata* and *Magnolia biondii* rootstocks with V-graft, veneer graft and side grafting techniques in spring in China. They reported that the highest success (95%) was obtained from veneer graft, the lowest success (20%) from side grafting on *Magnolia biondii* rootstock, and that shoots (57.6 cm) developed faster on *Magnolia denudata* rootstock.

The findings of the above-mentioned studies show that high grafting success can be achieved by utilizing appropriate grafting techniques and accurate grafting times for magnolias. In this study, the high success rates obtained from both spring patch and chip buddings under high tunnel conditions and summer patch buddings under open field conditions were consistent with the relevant references. In addition, success rates of 92-100% in patch budding dated 24 May and 30 May, 92-96% in chip budding dated April 19 and April 26, and 92% in patch budding dated August 29 and September 5 were remarkable. These data showed that magnolia (*Magnolia grandiflora* cv. Gallisoniensis) plants can be propagated with high success rates by patch and chip budding techniques in spring and summer periods.

On the other hand, one of the advantages of grafting in woody plants is that it physiologically encourages early flowering. Gu et al. [25] reported that grafting in the magnolia plant (*Magnolia liliflora* Desr.) could shorten the flowering onset time by more than 10 years compared to the ungrafted plant, and that the first flowers on the grafted plant were larger than those on the ungrafted one. In this study, the budded plants showed good growth under nursery conditions. Indeed, the average plant height growth was 186 cm for patch budded plants and 177 cm for chip budded plants after three growing seasons after budding. In addition, all budded plants bloomed 30 percent in the second growing season (2022) and 70 percent in the third growing season (2023). These findings were evaluated as successful in terms of plant development and early flowering.

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Conclusion

Patch budding success in spring was 100% with the small buds on May 24, and small and large buds on May 30. The average success rates for spring patch budding, spring chip budding and summer patch budding were 87.4%, 92% and 87%, respectively. The success of patch budding in spring and summer was not statistically affected by bud size. In addition, the success of patch budding in summer was not statistically influenced by rootstock thickness. On the other hand, at the end of three growing seasons after budding under nursery conditions, the average plant height growth in patch and chip buddings reached 186 cm and 177 cm, respectively. In addition, 30% of all budded plants bloomed in 2022 and 70% in 2023. In conclusion, in this study, successful results were obtained from the spring and summer budding studies of magnolia (*Magnolia grandiflora* cv. Gallisoniensis), an urban plant. It is considered that data would contribute to the related studies and relevant nursery sector.

Conflicts of Interest

The authors declare no conflict of interest.

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