

An evaluation of yellow-flowering magnolias and magnolia rootstocks

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Abstract

Yellow-flowering magnolias were evaluated for flower color, bloom duration and growth rate in USDA Hardiness Zone 6b. Of the 30 selections evaluated, all were reported to have yellow blooms; however, tepal color ranged from light pink with some yellow coloration, creamy yellow to dark yellow. 'Daphne', 'Judy Zuk', and 'Yellow Bird' have the darkest yellow tepals and would often be the last to bloom. 'Gold Star', 'Golden Gala', 'Stellar Acclaim', 'Sun Spire', and 'Sundance' had the lightest yellow tepal color. 'Goldfinch', 'Butterflies', and 'Elizabeth' were the earliest to bloom and 'Elizabeth' had one of the longest flowering periods. 'Carlos' and 'Gold Star' are the tallest selections at 7 m each after 10 years in the evaluation. 'Golden Gala', 'Gold Star', 'Carlos', 'Lois', and 'Yellow Lantern' had the largest trunk diameters and averaged over 2.5 cm growth per year. 'Sun Spire' has one of the smallest trunk diameters and shows an annual increase of about 1.5 cm per year. Powdery mildew incidence, *Phyllactinia corylea* and *Microsphaera alni*, was observed on all selections; however, 'Golden Sun', 'Solar Flair', 'Stellar Acclaim', 'Sunburst', 'Sunsation', and 'Yellow Bird' had greater than 40% of the leaf area affected with mildew with over 60% of the canopy affected by late summer. Powdery mildew was significantly less on 'Banana Split', 'Carlos', 'Elizabeth', and 'Sun Spire'. An evaluation of rootstocks revealed 'Leonard Messel' had more height growth occur with scions than selections budded onto other rootstocks in comparison to scions budded on to 'Wada's Memory' rootstock which produced the smallest height growth. Rootstocks 'Wada's Memory' and 'Ballerina' produced the smallest scion trunk diameter growth. After 5 years, bud incompatibility was observed on rootstocks 'Ballerina' and 'Leonard Messel' as indicated in the difference of growth between the rootstock and the scion.

INTRODUCTION

Deciduous magnolias are well adapted to many landscape situations and are highly desirable due to their floriferous nature. About 800,000 flowering magnolias are sold each year in the USA and about 10% of the nurseries that grow magnolias are located in Tennessee (USDA, 2014). There has been interest in breeding for deciduous yellow-flowering magnolias since the 1950s. Most of the yellow-flowering magnolias have been bred from a USA native magnolia, *Magnolia acuminata* or *M. acuminata* var. *subcordata*, a smaller stature than *M. acuminata*. This species provides cold hardiness and can be grown in a wide array of soil types. Hybridization with *M. denudata* or *M. liliflora*, native to China, can offer yellow flower color and a range of tree sizes and shapes. Most American magnolias bloom with the foliage, which means a late spring-summer bloom whereas the *M. denudata* bloom before the leaves emerge in the spring. Many selections of yellow magnolias bloom in late March-early April, but often spring frosts and freeze affects flowering as well as leaf out (Fare, 2011). Cultivars like 'Elizabeth', 'Yellow Bird', and 'Butterflies' were a few of the first commercially available. A second generation of yellow-flowering magnolias with cultivars like 'Golden Sun', 'Golden Gift', 'Gold Star', 'Yellow Lantern', and a well-known cultivar 'Butterflies' were developed by breeders Dr. David Leach and Philip Savage. Dr. August Kehr released 'Gold Cup', 'Solar Flair', 'Stellar Acclaim', 'Sundance' and 'Sun Ray' and in later years,

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he released 'Sunburst', 'Sunsation', and 'Sun Spire'. A notable cultivar, 'Lois', was developed by Lola Koerting (Knox, 2001). Yellow-flowering deciduous magnolias are becoming popular landscape plants because they offer an unusual color palette and there are very few yellow-flowering small trees in the landscape plant inventory (Knox, 2002).

This evaluation was conducted at the Tennessee State University Nursery Research Center located in middle Tennessee on the border of USDA Hardiness Zones 6 and 7. The area is known as a climatic and geographic transition zone. Plants produced in this area can be used in landscapes as far north as Zone 5 and as far south as Zone 8. Plant evaluations made in transition zones are ideal because results can be utilized over a wide geographic and climatic area.

The primary objective of this research project was to compare yellow-flowering magnolias for flower color intensity, flower size, and duration as well as growth rate and canopy form. It was noticed during the evaluation that bud incompatibility was occurring on some of the selections. Often, there was not a knowledgeable source as to the rootstock used during propagation. Thus, a second project was initiated in 2011 to evaluate known rootstocks with three selections, 'Elizabeth', a large canopy selection, 'Golden Pond', a moderate sized selection and 'Sun Spire', a slow upright growing selection.

MATERIALS AND METHODS

Plant evaluation

Many selections of yellow-flowering magnolias are only available in low numbers and small sizes so plants for this evaluation were purchased, grown in #3 or #5 containers for a year, and planted in the evaluation plot the following spring. The first plantings were in March 2006 in a field plot with well drained silt loam soil (Waynesboro) using a 4.6 m (15 ft) in-row spacing and 3.7 m (12 ft) between row spacing. Each magnolia selection was planted in a randomized block design with three single plant replications. Plants were maintained with traditional management including fertilization, mulching, and weed control. Pruning was limited to removing branches from the trunk about 61 cm (24 in.) above the soil line. In March 2007, a few weeks of unseasonably warm temperatures occurred followed by a hard freeze that lasted several days. Many plants had broken dormancy and as a result of the freeze were killed or suffered severe dieback. Plantings were reestablished and up to 37 selections of yellow-flowering magnolias have been under evaluation; however, several selections have died from subsequent spring freezes with damage to the trunks and or canopy (Magnolia Society, 2010). Flowering duration was determined from the first observation of flowers until flower tepals no longer had a visual impact. Data presented is an average time period that flowering occurred from 2008 through 2016. To determine flower color, three flowers per tree were removed on the day the flowers opened and color was measured on the inside and outside of the tepal using the Royal Horticultural Society Colour Chart (RHS, London, England) and a portable spectrophotometer (Minolta 2600d). Leaf-out was recorded from the time the foliage was at least 50% unfurled until full leaf.

Each fall, height, two canopy widths (perpendicular measurements) and trunk diameter [measured 15 cm (6 in.) above the substrate surface] were recorded. During June 2014, five leaves were removed from each tree to determine leaf size (CI-203, CID, Camas, Washington). Powdery mildew was rated during August, September, and October each year for the percentage of foliage affected and the percent of disease severity on the entire canopy (only data shown from October 2015). All data was statistically analyzed using the general linear model in SAS 9.1. Mean separation was performed with Fisher's protected LSD with alpha =0.05.

Bud incompatibility

Rooted cuttings of *M.* 'Ann' and 'Jane'; *M. × loebneri* 'Ballerina', 'Leonard Messel', and 'Merrill'; and *M. × kewensis* 'Wada's Memory' were potted into #3 nursery containers (Classic 2000, Nursery Supplies, Chambersburg, Pennsylvania) in April 2011 with a bark substrate amended with 9 lbs 19-5-9 Osmocote Pro, 1 lb Micromax and 1 lb AquaGro per yd. Plants

were grown in full sun until August 2011 when 'Sun Spire', 'Elizabeth', and 'Golden Pond' were budded onto the rootstocks. Plants were maintained in a shade house until late fall then placed in a plastic covered overwintering house. In late March 2012, rootstocks were transitionally pruned to the scion bud. Stakes were placed on the growing scion bud to ensure upright growth. Plants were grown under shade until spring 2013. Three plants of each budded selection on each rootstock were planted in a field with 10 ft between rows and 15 ft in-row spacing. The field soil had been tested prior to planting and treated with lime and phosphorus to bring the Waynesboro silt loam soil up to good growing conditions. Plants were maintained with traditional field management practices for fertilization, mulching, and weed control. Each fall, trunk diameter measurements were made 2.54 cm (1 in.) above and below the bud union. Magnolias were planted in a randomized block design with three single plant replications. All data was statistically analyzed using the general linear model in SAS 9.1. Mean separation was performed with Fisher's protected LSD with $\alpha = 0.05$.

RESULTS

Plant evaluation

Figure 1 shows the average time that flowering and leaf-out occurred from 2008 until 2015. Due to temperature fluctuations that occur during spring, in some years, unseasonably warm periods cause the flowers to mature quickly, thus the flowering period was shorter and in other years, late spring frosts resulted in poor flowering and delayed leaf-out. 'Goldfinch' is the earliest selection to bloom in mid-to-late March, followed by 'Butterflies' and 'Golden Pond'. 'Golden Pond', 'Sunsation' and 'Elizabeth' have flowering periods that often last up to 3 weeks; however, the best floral display is often during the mid-point and less showy in the beginning and end of the flowering period. 'Yellow Lantern' and 'Gold Star' have the shortest flowering periods which lasts about 1 week, then a distinct period of time before leaf-out occurs. The latest flowering magnolias are 'Sunsation', 'Yellow Bird' and 'Judy Zuk'. In most years, 'Sunsation' flowered about a week before 'Judy Zuk' and 'Yellow Bird'. 'Yellow Bird' is the most floriferous selection in the evaluation and may have more than twice the number of flowers than other selections.

With many selections, there was a distinct period between flowering and leaf-out, i.e. 'Butterflies', 'Carlos', 'Gold Star', 'Goldfinch', 'Sun Ray', and 'Sundance'. These selections started blooming in late March and leaf-out did not occur until early-mid April. Selections, 'Solar Flair', 'Sun Spire' and 'Sunburst', had overlapping periods of flowering and leaf-out, but leaf-out did not affect the floral display. However 'Judy Zuk' and 'Yellow Bird', two of the latest selections to flower, often had the floral display concealed by the foliage which unfurled during the peak flowering period.

One of the challenges with yellow-flowering magnolias is the tendency for the yellow flower color to vary from year to year or in certain climates not to develop fully. With many cultivars, the intensity of the yellow quickly fades into a soft creamy color. Color varies markedly from the inner side to the outer side of the tepal and from the basal end to the tip. Some selections, i.e., 'Sunsation' have flowers with an incursion of pink. With warmer spring temperature, color intensity is less than in the springs where the temperature has been cooler.

The Royal Horticulture Colour Chart was used to determine tepal color and the author found differences in this test compared to colors reported in the Magnolia Cultivar Checklist and other notable sources (Robinson, 2006; Fare, 2011). This is to be expected due to the maturity of the flower, location of the plant, and expected differences from year to year (Knox, 2001). The portable spectrophotometer used to measure color intensity also showed differences in color from tepal to tepal, plant to plant, and year to year; even though a more precise color was measured than what was dependent on the human eye with the color chart. 'Daphne', 'Judy Zuk', and 'Yellow Bird' have the highest yellow color reading on the spectrophotometer from year to year, even though the color intensity changes from year to year. 'Gold Star', 'Golden Gala', 'Stellar Acclaim', 'Sun Spire' and 'Sundance' have routinely had

the lightest yellow tepal color.

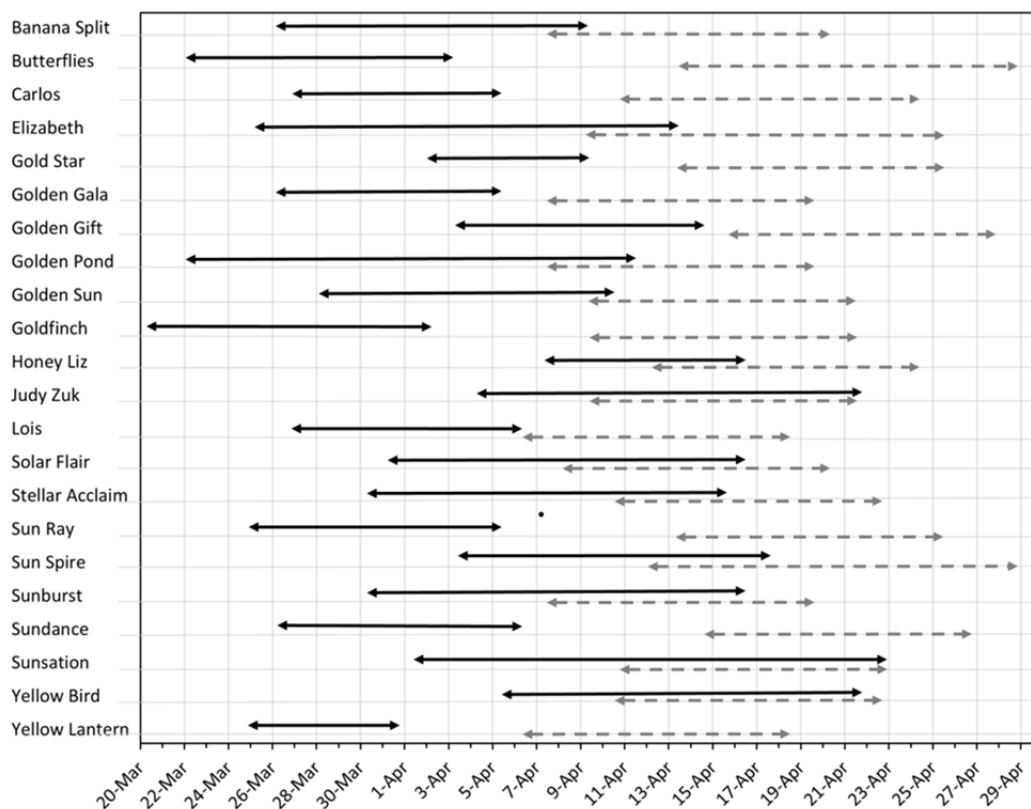


Figure 1. Flowering and leaf-out duration of selected yellow-flowering magnolias averaged from 2008 to spring 2015. Solid lines represent the flowering period and dashed lines represent the leaf-out period.

Since the initial planting, there are some distinct differences in canopy growth and development (Table 1). ‘Carlos’ and ‘Gold Star’ are the tallest selections at 708 and 699 cm, respectively. ‘Golden Gala’, ‘Judy Zuk’, ‘Yellow Lantern’, and ‘Yellow Bird’ have averaged about 85-95 cm of height growth annually. Several of the magnolias, such as ‘Solar Flair’, ‘Sun Spire’, ‘Sunsation’, and ‘Sunburst’ are slow growing and average about 60-65 cm a year in height. ‘Golden Rain’ and ‘Green Bee’ are currently the smallest magnolias in the test. Slow growth appears to be typical for many of the yellow-flowering magnolia selections during the first year or two after transplanting, but yearly height growth has increased after the third year in the test with many selections.

Canopy growth was calculated from an average of two canopy widths measured from one canopy drip line perpendicular to another (Table 1). Distinct canopy shapes were prominent with several cultivars. ‘Gold Star’, ‘Sundance’, ‘Lois’, and ‘Sun Ray’ have the widest canopies among the selections and could be labeled as broadly ovate. ‘Judy Zuk’ and ‘Sun Spire’ have a distinct upright growth habit and will probably become more distinct with age. On an annual basis, ‘Judy Zuk’ and ‘Sun Spire’ have about half the canopy width increase (~25 cm year⁻¹) compared to ‘Gold Star’ at 55 cm year⁻¹.

Trunk diameters were measured 30 cm (12 in.) above the soil surface in late fall. Trunk growth averaged from 1 cm to 2.6 cm per year during the evaluation (Table 1). ‘Golden Gala’, ‘Gold Star’, ‘Carlos’, ‘Lois’, and ‘Yellow Lantern’ had the largest trunk diameters and averaged over 2.5 cm (1 in.) growth per year compared to other selections. ‘Sun Spire’, planted in 2007, has one of the smallest trunk diameters and shows an annual increase of about 1.5 cm per year.

Table 1. Growth increase of height, canopy width and trunk diameter from March 2009 to December 2015 and average leaf area in 2015 of yellow flowering magnolias in Tennessee.

Selection	Height (cm)	Canopy width (cm)	Trunk diameter (cm)	Average leaf area (cm)
Anilou	557 a-h ¹	175 g-k	11.6 d-j	177 cde
Banana Split	555 a-h	193 f-k	12.1 c-j	184 bcde
Butterflies	444 e-i	180 g-k	9.6 hij	98 ghij
Carlos	708 a	278 b-g	18.2 ab	213 abc
Daphne	491 c-i	209 f-k	10.5 f-j	99 ghij
Elizabeth	560 a-h	243 d-i	15.8 a-g	141 efgh
Gold Cup	482 c-i	135 k	10.0 g-j	123 fghij
Gold Star	699 a	401 a	18.3 a	96 hij
Golden Gala	675 ab	346 a-d	18.4 a	236 a
Golden Gift	466 d-i	248 c-i	11.3 d-j	90 ij
Golden Pond	447 e-i	174 g-k	9.0 hij	154 defg
Golden Rain	345 i	172 g-k	8.0 ij	120 fghij
Golden Sun	491 b-i	240 e-k	11.1 e-i	148 defg
Goldfinch	560 a-h	193 f-k	11.5 d-j	105 ghij
Green Bee	355 i	139 jk	7.4 j	95 hij
Honey Liz	422 f-i	150 ijk	8.3 hij	178 cde
Judy Zuk	596 a-f	193 f-i	13.5 a-i	192 abcd
Koban Dori	419 ghi	169 h-k	7.5 ij	87 ij
Lois	579 a-f	372 ab	18.0 ab	167 cdef
Petit Chicon	515 b-i	167 h-k	9.7 hij	125 fghij
Skyland's Best	401 hi	199 f-k	9.6 hij	98 hij
Solar Flair	542 a-h	284 b-f	13.8 a-i	109 ghij
Stellar Acclaim	561 a-h	317 a-e	13.6 a-i	93 hij
Sun Ray	633 a-d	354 abc	17.0 abc	164 cdef
Sun Spire	541 a-h	150 ijk	12.4 b-j	126 fghij
Sunburst	558 a-h	287 b-f	16.0 a-e	85 j
Sundance	620 a-e	377 ab	17.5 abc	181 cde
Sunsation	481 c-i	187 f-k	16.7 a-d	233 ab
Yellow Bird	644 abc	258 c-h	14.1 a-h	147 defg
Yellow Lantern	667 ab	327 a-e	17.6 ab	213 abc
LSD	174	106	5.8	49

¹Means followed by the same letter within a column are not significantly different at $P \leq 0.05$, using Fisher's least significant difference test.

Leaves on the yellow-flowering magnolias vary in size (Table 1). 'Carlos', 'Golden Gala', 'Sunsation', and 'Yellow Lantern' are among the selections with the largest leaves. The foliage presents a very coarse textured canopy and may result in concerns with fall leaf litter. In contrast, 'Butterflies', 'Gold Star', 'Golden Gift', 'Stellar Acclaim', and 'Sunburst' have some of the smallest leaves among the selections in the evaluation. An identifying characteristic of 'Sun Spire' is the dark green foliage that is prevalent throughout the summer months. Flowering and leaf out are both affected by spring temperatures and late frosts, but in most years 'Judy Zuk', 'Solar Flair', 'Sunburst', 'Sunsation', and 'Yellow Bird' leaves mature while flowering is in the peak period. Leaf maturity often masks the flowers and thus flowering is not visible from short distances away.

Powdery mildew, *Phyllactinia corylea* and *Microsphaera alni*, has developed into a serious problem in the evaluation (Table 2). The foliar mildew appeared naturally and disease pressure has continued to be high in most years. No attempts have been made to

apply preventative fungicides in the evaluation. There were significant differences among cultivars in severity of powdery mildew. In October 2015, all selections had some incidence of powdery mildew on the foliage; however, the severity varies with plant selection. By mid to late summer, 'Golden Sun', 'Solar Flair', 'Stellar Acclaim', 'Sun Burst', 'Sunsation', and 'Yellow Bird' had greater than 40% of the leaf area affected with mildew with over 60% of the canopy was affected. Another selection, 'Gold Star' had 15% of individual leaf surface affected with powdery mildew but over 66% of the canopy was affected. Powdery mildew severity was significantly less on 'Banana Split', 'Carlos', 'Elizabeth', and 'Sun Spire' than on other selections.

Table 2. Severity of powdery mildew, *Phyllactinia corylea* and *Microsphaera alni*, on foliage of select yellow flowering magnolias, October 2015.

	Powdery mildew on individual leaves (%)	Powdery mildew on plant canopy (%)
Anilou	24.8 cde ¹	50.0 c-f
Banana Split	20.0 cde	20.0 h
Carlos	13.0 de	20.0 h
Elizabeth	10.0 de	16.7 h
Gold Cup	30.0 bcd	46.7 c-g
Gold Star	15.0 de	66.7 abc
Golden Pond	43.0 abc	30.0 e-h
Golden Rain	20.0 cde	58.3 bcd
Golden Sun	60.0 a	35.0 d-h
Goldfinch	30.0 bcd	25.0 fgh
Green Bee	47.0 ab	83.3 ab
Honey Liz	43.0 abc	80.0 ab
Judy Zuk	17.0 de	23.3 gh
Koban Dori	41.0 abc	70.0 abc
Lois	20.0 cde	28.3 e-h
Petit Chicon	30.0 bcd	21.7 gh
Solar Flair	60.0 a	35.0 d-h
Stellar Acclaim	47.0 ab	85.0 a
Sun Ray	13.0 de	21.7 gh
Sun Spire	3.0 e	13.3 h
Sunburst	50.0 ab	61.7 abc
Sundance	10.0 de	35.0 d-h
Sunsation	43.0 abc	51.7 cde
Yellow Bird	63.0 a	71.7 abc
Yellow Lantern	30.0 bcd	26.7 e-h
LSD	29.0	21.0

¹Values are the means of three replicate plots; means followed by the same letter within a column are not significantly different at $P \leq 0.05$, using Fisher's least significant difference test.

Bud incompatibility

In the plant evaluation test, it was obvious after a few years that the rootstock and scion growth was occurring at different rates with several of the cultivars which resulted in bud incompatibility and poor growth. Inquiries were made to the source of the original purchases of magnolias but a lack of records made it impossible to confirm the root stock of many of the plants. While it is possible for the scion to overgrow the rootstock and vice versa, a strong bond must be present in the callus bridge or incompatibility will occur. Overgrowth or undergrowth of the scion may be more related to genetic tendency for

growth than to incompatibility (Hartmann et al., 2002).

Five years after budding (3 years in the field plot), height growth was greater with 'Elizabeth' and 'Golden Pond' than 'Sun Spire' regardless of rootstock (Table 3). This was similar to results observed in the evaluation test; however, rootstocks had an effect on height growth. Selections chip budded on to 'Leonard Messel' had more height growth occur with scions than selections budded onto other rootstocks. The least amount of height growth occurred with scions budded on to 'Wada's Memory' rootstock compared to other rootstocks.

Table 3. Effects on growth of yellow flowering magnolias budded onto select magnolia rootstocks.

	Height (cm)	Trunk diameter (cm)	Difference in diameter of rootstock and scion bud (cm) ¹
Scions			
<i>M.</i> 'Sun Spire'	316.5 b ²	6.2 b	1.2 a
<i>M.</i> 'Elizabeth'	400 a	7.3 a	0.5 b
<i>M.</i> 'Golden Pond'	400.7 a	7.7 a	0.4 b
LSD		0.5	2.9
Rootstocks			
<i>M.</i> × <i>loebneri</i> 'Leonard Messel'	418.3 a	7.6 a	1.4 a
<i>M.</i> × <i>loebneri</i> 'Ballerina'	363.9 b	6.4 c	1.7 a
<i>M.</i> × <i>kewensis</i> 'Wada's Memory'	337.4 c	6.4 c	0.9 bc
<i>M.</i> × <i>loebneri</i> 'Merrill'	368.7 b	6.8 bc	1.1 bc
<i>M.</i> 'Ann'	382 b	7.4 ab	0.5 cd
<i>M.</i> 'Jane'	375.3 b	7.4 ab	0.2 d
LSD	19.9	0.7	0.5

¹Difference in rootstock and scion diameter was determined by measuring the trunk one inch above and below the bud union.

²Means followed by the same letter within a column are not significantly different at $P \leq 0.05$, using Fisher's least significant difference test.

Trunk diameters of scion growth (measured at 2.5 cm above the bud union) were largest with 'Elizabeth' and 'Golden Pond', 7.3 and 7.7 cm, respectively, compared to 'Sun Spire', 6.2 cm, which reconfirms that 'Sun Spire' is a slower growing selection of magnolia (Table 3). Trunk growth averaged 6.4 to 7.6 cm among scions, with significantly larger trunks on rootstocks of 'Ann', 'Jane', and 'Leonard Messel'. 'Wada's Memory' and 'Ballerina' rootstocks produced the smallest trunk diameter of scion growth among the selections.

The difference in trunk diameter above and below the bud union showed that 'Ballerina' and 'Leonard Messel' had the greatest difference in growth between the rootstock and the scion. 'Ballerina', for example, averaged a difference of 1.7 cm among all the scions; however, specifically with 'Sun Spire', 'Elizabeth', and 'Golden Pond' there was a difference of 2.2, 1.7 and 1.2 cm, respectively. In contrast, 'Ann' and 'Jane' rootstocks averaged less than 0.5 and 0.2 cm, respectively, with trunk diameter difference above and below the bud union. There were instances, especially with 'Golden Pond' where the scion diameter grew more than the diameter of the rootstock. In the future, selections matching growth of the rootstocks to the scion may be chosen from genetic information that will eliminate time in choosing parents and or rootstocks (Ranney and Gillooly, 2015).

CONCLUSION

A comprehensive replicated evaluation of new and familiar yellow-flowering magnolias in one location will benefit magnolia connoisseurs, the nursery industry, and prospective plant breeders. In time, more valuable information will be collected as the plants grow in the evaluation and as the evaluation on rootstock with bud incompatibility matures. As yellow-flowering magnolias become more widely known, many selections in this

evaluation may be less popular and will serve only as a breeding line for developing improved selections. Time of flowering is critical for plants in USDA Hardiness Zones 6 and 7 due to early spring frosts (and freezes) and will be the deciding factor to the success of many yellow-flowered selections (Tubesing, 1998). The palette of yellow color is well represented with the *Magnolia* selections from border-line creamy yellow to distinctly yellow in color (Cover, 2009). However, in this evaluation, the selections that flowered after the threat of spring frosts also leafed-out during the flowering period which caused a lesser flowering impact than earlier blooming selections.

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