A comprehensive evaluation of yellow-flowering *Magnolias*

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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 US and about 10% of the nurseries that grow them are located in Tennessee (USDA, 2010). Yellow-flowering deciduous magnolias are becoming popular landscape plants because they offer an unusual color palette (Knox, 2002). There are very few yellow-flowering small trees in the landscape plant inventory.

This research project was conducted at the Tennessee State University (TSU) Nursery Research Center located in the heart of the nursery industry in Tennessee on the border of USDA Hardiness Zones 6 & 7. The area is known as a climatic and geographic transition zone. Plants raised in this area can be used in landscapes in 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. A secondary goal was to develop a performance record of magnolias planted in a replicated trial in one location to assist plant breeders for future plant development.

Materials and Methods

Many selections of yellow-flowering magnolias are only available in low numbers and small sizes. For this project, plants were purchased, grown in a #3 or #5 container for a year, and planted in the evaluation plot the following spring. Magnolias were first planted in March 2006 in a field plot with 4.6 m (15 ft) in-row spacing and 3.7 m (12 ft) between rows in a well-drained silt loam soil (Waynesboro). 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. Irrigation was applied during the growing season in periods of drought. In March 2007, unseasonably warm temperatures occurred. Many plants had broken dormancy and were leafing out. Within a couple of weeks in early April 2007, a hard freeze occurred, lasting for several days. Many of the magnolia selections were killed or suffered severe dieback. Plantings were reestablished. Currently, we have 37 selections of yellow-flowering magnolias under evaluation (Magnolia Society, 2010). Due to the differ-

ent planting dates (Table 1), growth data presented in Tables 1 and 2 were calculated by subtracting height and caliper measurements in the spring from fall measurements to determine growth during each year. In 2009 and 2010, 5 leaves were selected from each plant to determine leaf area (only data from 9 June 2010 shown). Flowering duration was determined from recording the first flower to the last flower when tepal color no longer had a visual impact. On the first day that selected flowers opened, three were selected to determined tepal color using the Royal Horticultural Society color chart and a portable spectrophotometer (Minolta 2600d) (only data from April 6 and April 9, 2010 shown). 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 and Discussion

In 2007, plant growth was slow due to the effect of the April freeze. During 2008 to 2010, *Magnolia* 'Goldfinch', *M.* 'Gold Star' and *M.* 'Banana Split' had the greatest average height growth of 114 cm, 99 cm and 97 cm, respectively (Table 1). The slowest growing selection was *M.* 'Golden Sun' with an average of 22 cm during 2009 to 2010. Slow growth appears to be typical for many of the yellow flowering magnolia selections during the first year or two after transplanting. Yearly height growth increased after the third year in the test with many selections.

Table 1. Date planted and height growth of selected yellow-flowering *Magnolia* selections in McMinnville, Tenn from 2006 - 2010.

		Height growth, cm[Z]				
Selection[Y]	Date Planted	2006	2007	2008	2009	2010
Anilou[Y]	2010	-	-	-	-	-
Banana Split	2009	-	-	-	109 a	85 bcd
Blue Opal[Y]	2010	-	-	-	-	-
Brenda[Y]	2010	-	-	-	-	-
Butterflies	2006	97 a[X]	23 bcd	70 bcd	58 a-f	78 bcd
Carlos	2009	-	-	-	69 a-f	115 ab
Coral Lake[Y]	2009	-	-	-	-	-
Daphne[Y]	2010	-	-	-	-	-
Daybreak	2007	-	2 d	18 cde	85 a-e	73 bcd
Elizabeth	2006	42 bc	-	49 cd	7 g	74 bcd
Evamaria	2009	-	-	-	76 a-f	86 bcd
Gold Cup[Y]	2010	-	-	-	-	-
Gold Star	2006	100 a	47 abc	239 a	31 efg	80 bcd
Golden Gala	2009	-	-	-	70 a-f	90 bcd
Golden Gift	2007	-	107 a	35 e	31 efg	24 e
Golden Pond[Y]	2010	-	-	-	-	-
Golden Rain[Y]	2010	-	-	-	-	-
Golden Sun	2009	-	-	-	47 c-f	65 cde
Goldfinch	2008	-	-	85 bc	109 a	148 a

Table 1. Cont.

Selection[Y]	Date Planted	Height growth, cm[Z] 2006	2007	2008	2009	2010
Green Bee[Y]	2010	-	-	-	-	-
Honey Liz[Y]	2010	-	-	-	-	-
Illini Gold[Y]	2010	-	-	-	-	-
Illini Moonlight[Y]	2008	-	-	-	-	-
Judy Zuk	2008	-	-	-	78 a-f	95 bcd
Koban Dori[Y]	2010	-	-	-	-	-
Lois	2007	-	49 ab	53 cd	56 b-f	74 bcd
Miss Honeybee	2008	-	2 d	86 bc	91 a-d	69 cde
Petit Chicon[Y]	2010	-	-	-	-	-
Skyland's Best[Y]	2010	-	-	-	-	-
Solar Flair	2006	30 bc	24 bcd	49 cd	74 a-f	70 bcd
Stellar Acclaim	2007	-	45 abc	53 cd	68 a-f	103 abc
Sun Ray	2006	38 bc	2 d	77 bcd	52 c-f	74 bcd
Sun Spire	2007	-	5 bcd	39 cde	71 a-f	72 bcd
Sunburst	2006	79 ab	22 bd	60 bcd	27 fg	66 de
Sundance	2006	55 ab	19 bcd	83 bc	63 a-f	78 bcd
Sunsation	2006	-	23 bcd	65 bcd	82 a-e	51 de
Yellow Bird	2008	-	-	133 b	61 a-f	68 cde
Yellow Lantern	2009	-	-	-	104 abc	75 bcd
LSD		50	2	75	54	6

[Z]Height growth in 2006 = measurements made in Dec 2006 - April 2006; 2007 height growth = measurements made in November 2007 - March 2007; 2008 height growth= measurements made in December 2008 - March 2008; 2009 height growth = measurements made in November 2009 - March 2009; 2010 height growth = measurements made in November 2010 - March 2010.

[Y]Selections have been planted in the evaluation, but have not been planted long enough to report results.

[X]Treatments followed by the same letter are not significantly different. Means separated using Fisher's protected LSD, $\alpha \leq 0.05$.

Trunk diameters were measured 30 cm (12 in) above the soil surface. Trunk growth averaged from 9 mm to 29 mm during the test (Table 2). *M.* 'Carlos', *M.* 'Yellow Lantern', *M.* 'Sundance', *M.* 'Gold Star' and *M.* 'Golden Gala' had the most trunk diameter increase and averaged over 25 mm (1 in) growth per year. *M.* 'Golden Gift', *M.* 'Daybreak', *M.* 'Golden Sun' and *M.* 'Solar Flair' had the least trunk diameter growth increase with yearly averages of 9 mm, 11 mm, 12 mm and 14 mm, respectively. Other selections had an intermediate increase in trunk diameter.

Canopy growth was calculated from an average of 2 canopy widths measured from one drip line perpendicular to another in 2008, 2009 and 2010 (Table 2).

Table 2. Trunk diameter growth and canopy width of selected yellow-flowering *Magnolia* selections in McMinnville, Tenn from 2007 - 2010.

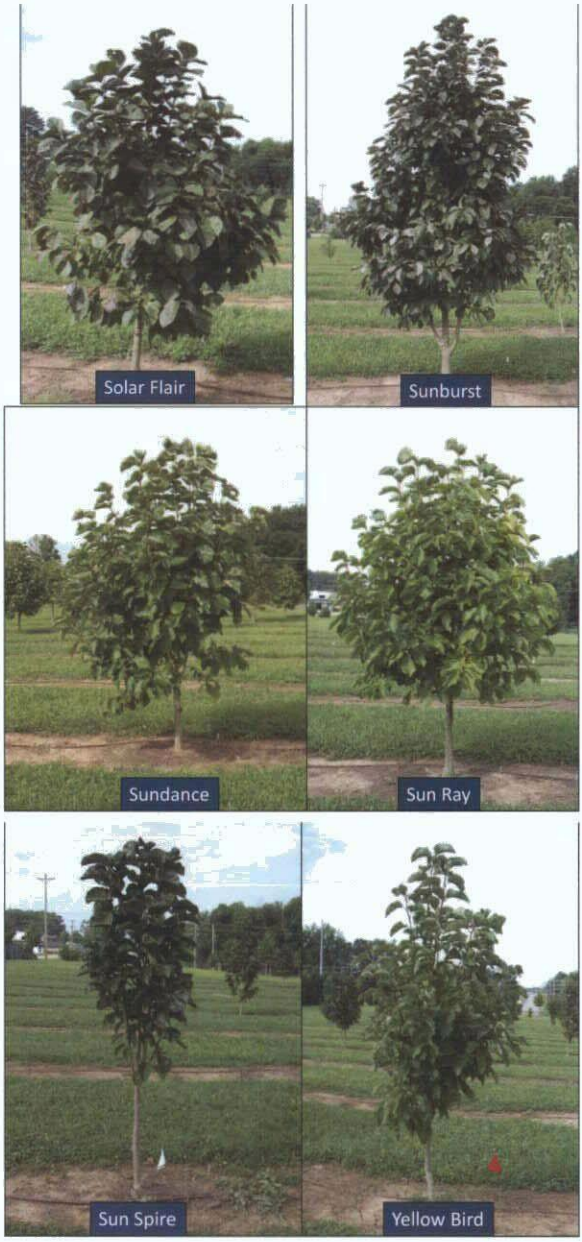
	Trunk caliper growth, mm[Z]				Canopy width, cm[Z]		
Selection	2007	2008	2009	2010	2008	2009	2010
Banana Split	-	-	19 ab	19 b	16 gh	34 ghi	72 fgh
Butterflies	23 a[Y]	27 bc	25 ab	20 b	158 a	155 ab	225 ab
Carlos	-	-	21 ab	30 ab	12 gh	54 e-i	128 d-h
Daybreak	-	2 e	14 ab	16 b	8 gh	25 i	62 h
Elizabeth	22 a	19 bcd	2 b	16 b	109 bcd	119 abc	149 cde
Evamaria	-	-	28 ab	10 b	14 gh	48 f-i	80 e-h
Gold Star	5 b	58 a	10 ab	37 ab	125 abc	163 a	231 a
Golden Gala	-	-	28 ab	29 ab	29 fgh	70 c-i	160 a-d
Golden Gift	-	2 e	14 ab	10 b	53 efg	83 c-i	99 d-h
Golden Sun	-	-	12 ab	12 b	17 gh	27 hi	68 gh
Goldfinch	-	6 de	29 ab	24 ab	21 gh	58 d-i	104 d-h
Judy Zuk	-	-	15 ab	21 b	6 h	28 ghi	68 gh
Lois	-	19 bcd	19 ab	21 b	75 def	113 a-d	147 c-f
Miss Honeybee	-	12 cde	30 a	24 ab	16 gh	64 c-i	110 d-h
Solar Flair	14 ab	-	19 ab	22 ab	83 cde	106 a-e	155 bcd
Stellar Acclaim	-	13 cde	18 ab	21 b	51 e-h	78 c-i	143 c-g
Sun Ray	17 a	22 bcd	2 b	44 ab	143 ab	161 a	207 abc
Sun Spire	-	13 cde	16 ab	17 b	13 gh	34 ghi	75 e-h
Sunburst	21 a	33 b	1 ab	11 b	104 bcd	103 b-e	142 c-g
Sundance	18 a	21 bcd	2 b	63 a	14 ab	162 a	209 abc
Sunsation	-	17 cde	22 ab	30 ab	25 gh	54 e-i	88 d-h
Yellow Bird	5 b	19 bcd	20 ab	16 b	48 e-h	85 c-g	122 d-h
Yellow Lantern	-	-	26 ab	26 ab	22 gh	52 e-i	119 d-h
LSD	9	15	49	1	47	59	75

[Z]Trunk diameter growth was not meaured in 2006 and canopy width was not measured in 2006 and 2007; 2007 trunk diameter = measurements made in November 2007 - March 2007; 2008 trunk diameter and canopy width = measurements made in December 2008 - March 2008; 2009 trunk diameter and canopy width = measurements made in November 2009 - March 2009; 2010 trunk diameter and canopy width = measurements made in November 2010 - March 2010.

[Y]Treatments followed by the same letter are not significantly different. Means separated using Fisher's protected LSD, $\alpha \leq 0.05$.

By 2010, distinct canopy shapes were prominent with several cultivars. *M.* 'Sun Ray', *M.* 'Gold Star' and *M.* 'Butterflies' had the widest canopies among the selections and could be labeled as broadly ovate. These plants, along with *M.* 'Solar Flair', *M.* 'Elizabeth' and *M.* 'Sundance', were replanted in 2007 after the freeze and had been evaluated for the longest period of time. *M.* 'Sunburst', *M.* 'Sun Spire' and *M.* 'Golden Gala' had the most upright growth habit and will probably become more distinct with age. Other selections in the evaluation have not been evaluated long enough to determine a distinct canopy form (Figure 1).

Figure 1. Canopy form of selected yellow-flowering *Magnolias* in McMinnville, Tenn. Images were taken in summer 2010.

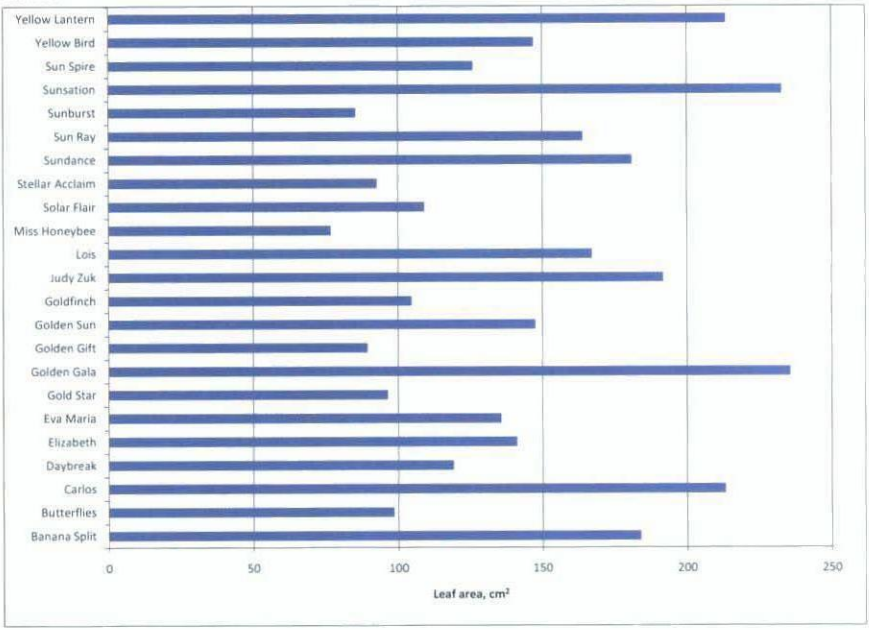


Foliage

Foliage on the yellow-flowering magnolias were distinctly different among selections and a few with large leaves had an impact on the visibility of the spring flowering. A CID leaf area meter, CI-203, was used to measure the surface area of leaves to determine the leaf size (Figure 2). *M.* 'Carlos', *M.* 'Golden Gala', *M.* 'Sunsation' and *M.* 'Yellow Lantern' had the

largest leaves, which presented a coarse texture leaf form. In contrast, *M.* 'Butterflies', *M.* 'Gold Star', *M.* 'Golden Gift', *M.* 'Miss Honeybee' and *M.* 'Sunburst' had the smallest leaves.

Figure 2. Leaf area of selected yellow-flowering *Magnolias* in McMinnville, TN on 9 June 2010.



Powdery Mildew

Powdery mildew (*Erysiphe magnifica*) has developed into a serious problem in the evaluation (Figure 3). The percent of powdery mildew (PM) incidence on individual leaves and the percent of incidence on the total leaves per tree were rated during the summer months in 2008, 2009 and 2010 (only 16 Aug 2010 data shown in Table 3). All selections had some incidence of PM; however, by mid to late summer several selections had severe incidence. Greater than 40% of the leaf area of *M.* 'Daybreak', *M.* ' Evamaria', *M.* 'Golden Gala', *M.* 'Golden Sun', *M.* 'Solar Flair', *M.* 'Stellar Acclaim', *M.* 'Sunburst', *M.* 'Sunsation' and *M.* 'Yellow Bird' had become affected by PM and over 60% of all the leaves on the plants had PM. Although only 15% of individual leaf surface of *M.* 'Gold Star' was affected with PM, every leaf on the tree had PM. *M.* 'Sun Spire' and *M.* 'Carlos' showed the least amount of PM on individual leaves and on the total leaves per tree. Two popular selections in the nursery trade, *M.* 'Butterflies' and *M.* 'Elizabeth', had PM similar to *M.* 'Sun Spire' and *M.* 'Carlos'. In Figure 4, the progression of PM during 2010 is shown with *M.* 'Gold Star', *M.* 'Solar Flair' and *M.* 'Stellar Acclaim'. Near the end of the summer, new foliage growth does not have the presence of PM, probably due to the unfavorable host environment.

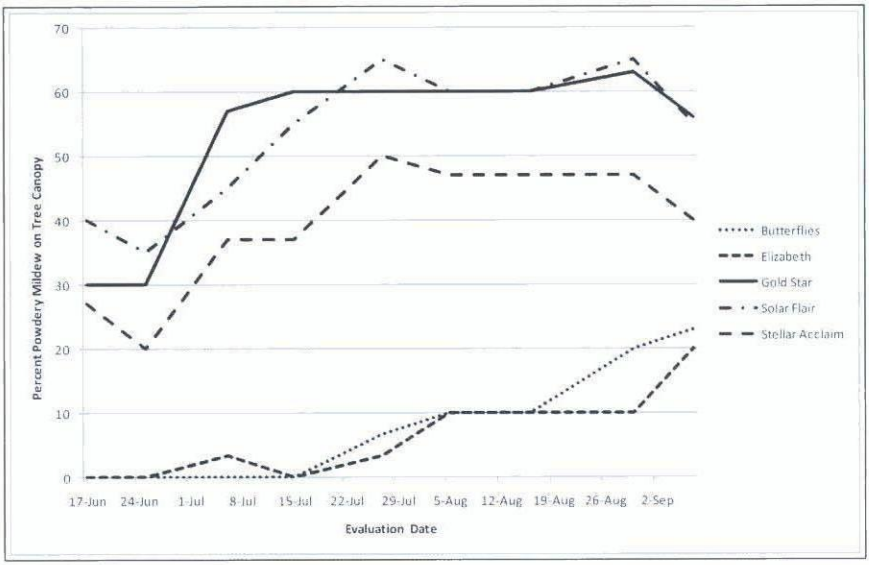
Figure 3. *M.* 'Gold Star' and *M.* 'Stellar Acclaim' foliage with incidence of powdery mildew, photographed September 2010.

Table 3. Percent of powdery mildew incidence on individual leaves and percent of total leaves affected on 16 Aug 2010 with yellow-flowering *Magnolia*.

Selection	% powdery mildew on individual leaves	% powdery mildew on total leaves per tree
Banana Split	20.0 cde[Z]	20.0 fg
Butterflies	10.0 de	27.0 fg
Carlos	13.0 de	17.0 g
Daybreak	50.0 ab	90.0 abc
Elizabeth	10.0 de	25.0 fg
Evamaria	45.0 ab	95.0 ab
Gold Star	15.0 de	100.0 a
Golden Gala	43.0 abc	60.0 de
Golden Gift	20.0 cde	70.0 b-e
Golden Sun	60.0 a	65.0 cde
Judy Zuk	17.0 de	30.0 fg
Lois	20.0 cde	47.0 ef
Solar Flair	60.0 a	100.0 a
Stellar Acclaim	47.0 ab	100.0 a
Sunburst	50.0 ab	80.0 a-d
Sundance	10.0 de	20.0 fg
Sun Ray	13.0 de	30.0 fg
Sun Spire	3.0 e	3.0 g
Sunsation	43.0 abc	83.0 a-d
Yellow Bird	63.0 a	90.0 abc
Yellow Lantern	30.0 bcd	23.0 fg
LSD	29	21

[Y]Treatments followed by the same letter are not significantly different. Means separated using Fisher's protected LSD, $\alpha \leq 0.05$.

Figure 4. Powdery mildew rating on 5 selected yellow-flowering *Magnolias* during 2010.



Time of flowering, flowering duration, flower size and color was recorded each spring. Flowering duration is shown in Figures 5 and 6 for 2009 and 2010, respectively. Each yellow bar represents the flowering duration from beginning to end. Often, the peak bloom period is for a short period of time near the middle of the bar. *M.* 'Butterflies' was the earliest to bloom in 2009 and 2010 followed by *M.* 'Elizabeth', which had one of the longest flowering periods during 2009 and 2010. During 2010, spring temperatures were unseasonably warm during the flowering period and flowers matured very quickly; thus, the flowering period was shorter for most selections than in 2009.

Each green bar represents leaf-out from the time the foliage was at least 50% unfurled. Some selections, i.e., *M.* 'Sun Spire', *M.* 'Sunburst' and *M.* 'Yellow Bird' (Figure 7), leafed-out during the flowering period, which masked the impact of the yellow flowers. Observations show the foliage consistently unfurls and fully expands in a short time frame, about 10 to 14 days. The early green foliage thus masks the yellow tepals, regardless of the yellow intensity.

Figure 5. Bloom and leaf-out duration of selected yellow-flowering *Magnolias* in spring 2009. Yellow bars represent the flowering duration and green bars represent the leaf-out period.

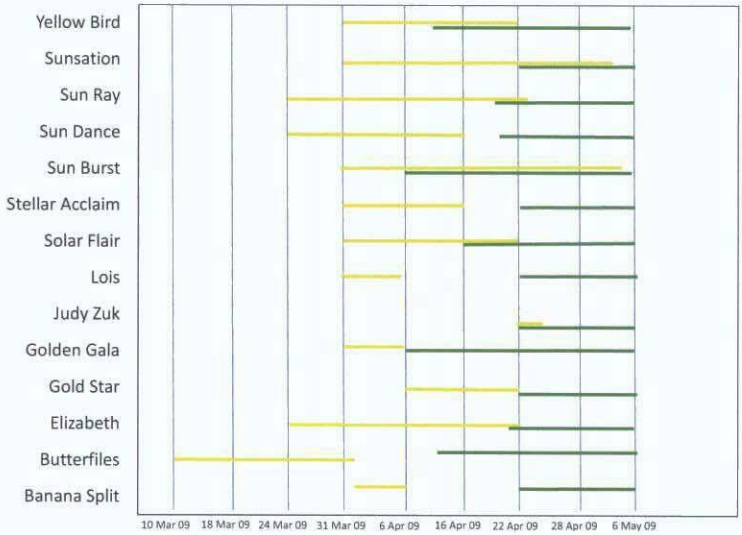


Figure 6. Bloom and leaf-out duration of selected yellow-flowering *Magnolias* in spring 2010. Yellow bars represent the flowering duration and green bars represent the leaf-out period.

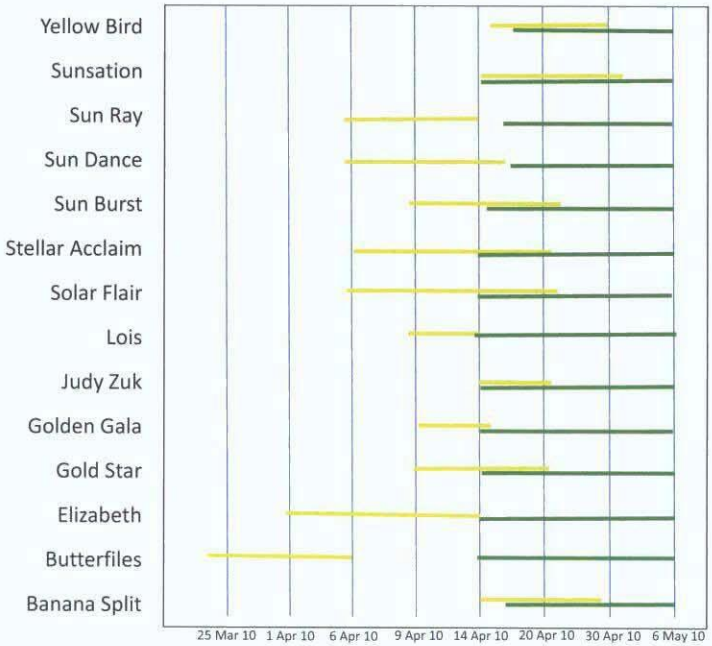
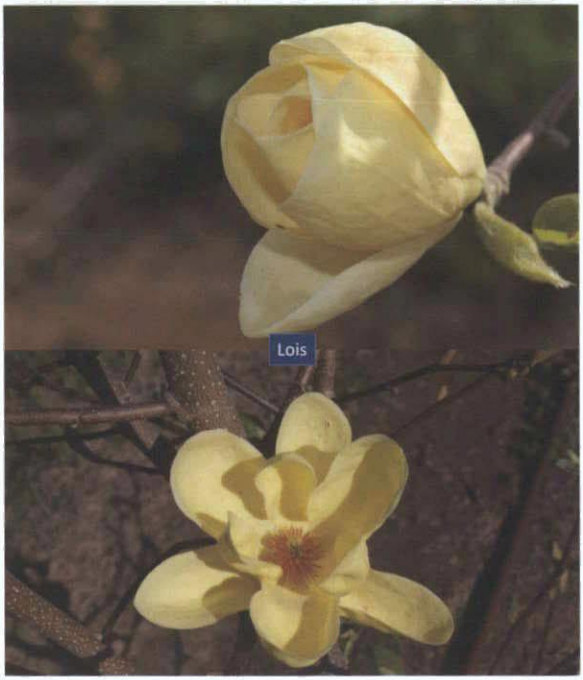
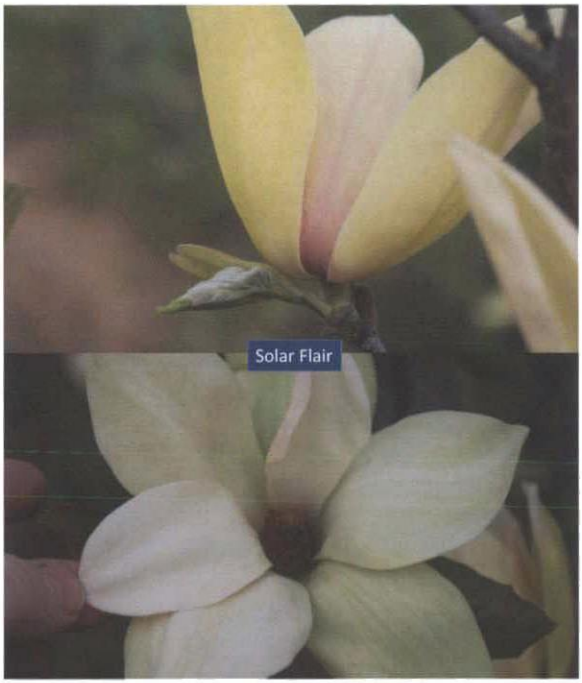


Figure 7. Images of selected yellow-flowering *Magnolias* in McMinnville, Tenn.

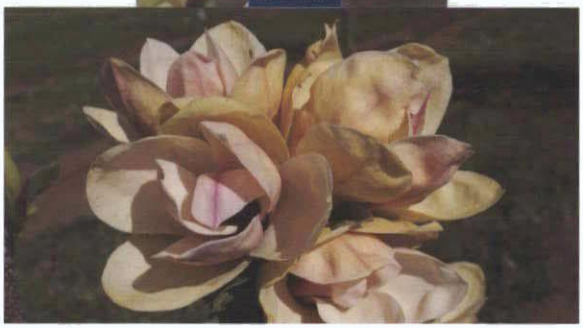

Golden Gift


Lois

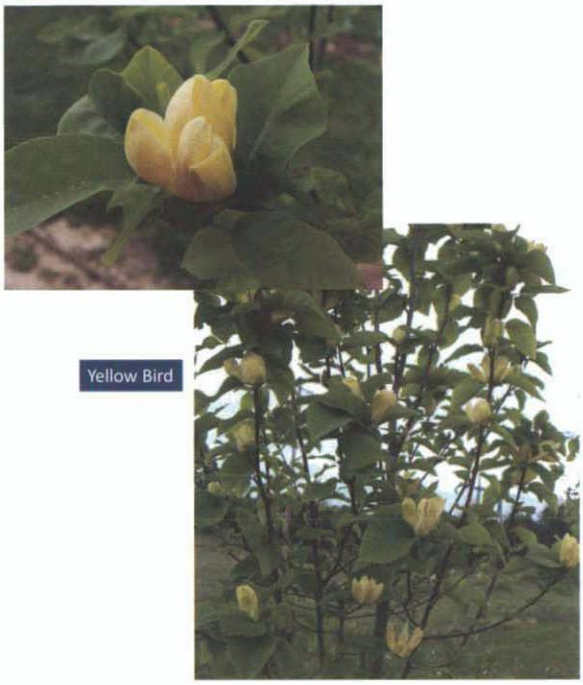

Solar Flair


Sunburst

Sunsation



Sun Spire



A portable spectrophotometer (Minolta 2600d) was used to measure color intensity. Three parameters in the following model represent the lightness of the color: L* at 0 = black and L* at 100 = white; a* with negative values indicate green while positive values indicate magenta and its position between yellow and blue; and b* with negative values indicate blue and positive values indicate yellow (Table 4). The Royal Horticulture Color Chart was used to define tepal color. Samples were read near solar noon on 6 April 2009 and 9 April 2010.

Tepal color varied markedly from the inner side to the outer side and from the basal end to the tip. Some magnolias had flowers with an intrusion of pink and in some cases the prominence of pink overwhelmed the yellow, as seen in *M.* 'Coral Lake', *M.* 'Daybreak' and *M.* 'Evamaria'. All reported measurements in this test were made near the center of the tepal on the outer side.

There are differences in the tepal color in this test compared to colors reported in the *Magnolia* Cultivar Checklist and other notable sources (Robinson, 2006). 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). Since all colors are detected with the spectrophotometer, more precise color intensity can be measured and provide results similar to what the

human eye perceives. Based on the parameter b*, the higher the number, the more yellow the color; therefore *M.* 'Judy Zuk' and *M.* 'Yellow Bird' have the highest yellow reading. *M.* 'Sun Spire', *M.* 'Sundance', *M.* 'Gold Star', *M.* 'Golden Gala' and *M.* 'Stellar Acclaim' had the lightest yellow intensity with b* values of 21.4, 22.2, 22.4, 22.6 and 22.8, respectively.

Conclusion

Table 4. Color parameters of selected yellow-flowering *Magnolias* determined by a portable spectrophotometer, Minolta 2600d.

	Color parameters, April 2009[Z]			RHC[Y]	
Selection	L*	a*	b*	6 April 2009	9 April 2010
Banana Split	73.9	-2.8	28.1	-	-
Butterflies	73.1	-2.7	32.7	4c	-
Elizabeth	71.2	-0.6	33.6	2d	4d
Gold Star	73.5	-2.1	22.4	4d	-
Golden Gala	74.2	-2.5	22.6	6d	-
Golden Gift	70.2	-1.2	32.3	6d	-
Golden Sun	73.1	-2.4	25.0	-	-
Judy Zuk	66.7	1.8	38.9	-	-
Lois	72.9	-1.8	28.2	5d	8c
Solar Flair	68.8	-3.2	30.6	4c	4c
Stellar Acclaim	67.4	0.6	22.8	5d	-
Sun Ray	72.7	-1.0	31.2	2d	4d
Sun Spire	70.2	-0.8	21.4	-	-
Sunburst	71.1	-1.3	25.9	5d	6d
Sundance	75.2	-3.2	22.2	2d	8c
Sunsation	69.2	-2.3	26.9	6d	-
Yellow Bird	68.3	-2.1	34.0	5d	-

[Z]L* at 0 = black and L* at 100 = white; a* with negative values indicate green while positive values indicate magenta and its position between yellow and blue; and b* with negative values indicate blue and positive values indicate yellow. Spectrophotometer measurements are taken excluding the specular reflection to provide measurement results similar to those observed by the human eye.

[Y]Royal Horticultural Colour Chart

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 mature in this evaluation.

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, as yellow-flowering magnolias become more widely known, many selections may be less popular for the common landscape and will serve only as a breeding line for developing improved selections. Time of flowering is critical for plants in US Hardiness Zones 6 and 7. Early spring frost (and freezes) can be detrimental on spring flowering as well as the leaf-out period. In this evaluation, many selections leafed-out during the

flowering period which caused the flowering to have less impact because the yellow tepals were masked by the early green foliage. This timing, as well as flower color, will be critical to the popular success of many yellow-flowered selections (Tubesing, 1998).

Another issue that needs to be addressed is the compatibility of the root system. Several individual plants have died or are showing signs of graft incompatibility. Swollen stem tissue above and below the bud union is becoming more prevalent as some of the plants mature. Several propagators queried revealed that three root stocks are routinely used: *Magnolia* 'Jane', *M. kobus* or *M. acuminata*; however, the root stocks of the plants in this evaluation are not known. Further research is needed to identify the most compatible root stock for the yellow-flowering *Magnolia* hybrids.

Acknowledgement

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