The Performance of Ten Imported Tree and Shrub Species Grown Under the Environmental Conditions of Riyadh Region, Saudi Arabia

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Abstract: The performance and growth of ten imported tree and shrub species were evaluated under the environmental conditions of Riyadh region, Saudi Arabia. The tree species were *Acacia visco*, *Acacia salicina*, *Acacia pruinocarpa*, *Leucaena greggii,* while the shrubs were *Caesalpinia mexicana, Parkinsonia florida, Senna artemisioides* x*sturtii, Senna artemisioides* x*artemisioides, Senna artemisioides filifolia,* and *Sophora tomentosa*. One year old seedlings were planted in the field and left to grow naturally. Plant growth measurements were taken at an interval of two months for one year**.** *Leucaena greggii* gave the highest values of plant height (4.64m), and crown diameter (2.6m) and had the longest flowering period and highest flowering rate percentage. *Acacia salicina* also reached 4 m in height and gave the highest values of stem diameter (10.87cm), number of branches (24) and crown height (3.94m). *Acacia pruinocarpa* gave the lowest plant height (2.41m), crown height (2.27m) and number of branches (17), while *Acacia visco* gave the lowest stem diameter (7.57cm) and crown diameter (2.03m) and had no blooming during the study period. The shrub species measurements showed that *Caesalpinia mexicana* gave the highest values of plant height (2.83m), crown height (2.63m) and stem diameter (9.5cm) while *Sophora tomentosa* gave the lowest plant height (1.07m), crown height (0.97m) and stem diameter (4.11cm). The *Senna artemisioides* subspecies were blooming continuously, giving mass of uniform yellow flowers for ten months, and the highest flowering rate occurred in March. These species grow in round shape and have aesthetic characteristics which allow them to be suitable for landscape uses. Generally the tree and shrub species performed very well under the arid environmental conditions of Riyadh region.
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Keywords: imported tree and shrub species, *Acacia spp*., *Senna artemisioides*, arid climate, Riyadh region, Saudi Arabia

Abbreviations: pH- potential of hydrogen; EC- electrical conductivity; TDS- total dissolved salts; ppm- part per million; RCBD- randomized complete block design; SAS- statistical analysis system ; LSD- least significant difference

1. Introduction

There are some ornamental tree and shrub species that own aesthetic characteristics, suitable for various landscape uses and also have the ability to withstand diverse situations and climates, especially in arid and semi-arid regions. These plants have important values in landscape uses of urban streets, squares, gardens and parks, in addition to their environmental advantages such as reducing pollution, extensity of heat and sun rays. Most of the desirable physical and horticultural features of tree species generally include evergreen leaves, intensive colorful flowers, thornless branch structure, columnar stem and vigorous growth (Taylor, 1993). These trees can be used as accent in streetscapes, parks and gardens. Some researchers have studied the growth performance of certain exotic tree species under their local environments (Aref, 2005; El-Osta et al., 1992; Tesfaye, 1994). In semiarid areas, multiple purpose trees and shrubs offer drought tolerance, low labor, supplement or alternative to agricultural crops for fodder, fuel and wood (Tesfaye, 1994). Some trees can also reduce soil salinization, thus improve the plant production (Schofield, 1992). In many arid zone countries, green belts consisted of various adapted tree species were planted around cities to protect people, environment and infrastructures against dust storms and encroaching sands and to modify the microclimate (Malagnoux et al., 2007). Xeriscape plants are drought tolerant, meaning they can survive extended periods of drought with little or no supplemental irrigation (Fletcher and waterfall, 1998). These kinds of plants are tolerant of desert-like conditions as low humidity low rainfall, and alkaline soils.

There are many desert tree species that may exhibit desirable characteristics for landscape applications and offer various forms and structures similar to other trees and shrubs naturally grown in the local environment (Taylor, 1993). Many native tree species thrive in hot dry sites, survive and grow well in arid climate. They tolerate extreme temperatures, infrequent irrigation and drought

conditions. Those trees have evolved certain characteristics such as unique leaf structure or special root systems that allow them to survive their region harsh conditions and withstand periods of drought (Sharma and Tewari, 2009). Some desert tree and shrub species have adapted to the severe conditions by reducing leaf size or eliminating leaves and replacing them with thorns, or by developing extremely long root system to draw water from deep underground near the water table. Most of acacia species are important sources of browse, fuel, pole timber, some can be used for shade, shelter, live fences, soil stabilization as well as street trees and ornamentals (Aref et al., 2003).

There are also some ornamental tree and shrub species that were imported many years ago which adapted and grew well under the environmental conditions of Saudi Arabia. These conditions include scarcity of water, low soil fertility, high salinity, high temperature and drought especially during the summer season. Adopting a tree species to be planted over a large scale in Saudi Arabia must take in consideration their ability to cope with prevailing environmental conditions in terms of survival and growth and offers additional benefits and uses to community (Aref, 2005). In arid regions with harsh desert conditions such as Riyadh, Saudi Arabia there is a real need for adopting more tree and shrub species that can tolerate these conditions and also possess the aesthetic characteristics. This study aimed to evaluate the performance and growth of 10 imported tree and shrub species under the environmental conditions of Riyadh region, Saudi Arabia. It also aimed to determine the aesthetic characteristics of these species which allow them to be suitable for landscape uses.

2. Materials and Methods

The study was conducted at the Nursery of the General Administration of Gardens

and Landscaping, Riyadh Municipality, Saudi Arabia, during March, 2009 to May, 2010. Seeds of several desert tree and shrub species were provided by Desert Legume Program, The University of Arizona, Tucson, AZ, USA. Ten different tree and shrub species were selected for this study; four tree species: *Acacia visco, Acacia salicina, Acacia pruinocarpa, and Leucaena greggii;* six shrub species: *Caesalpinia mexicana, Parkinsonia florida, Senna artemisioides ssp. sturtii, Senna artemisioides* ssp. *artemisioides, Senna artemisioides* ssp. *filifolia,* and *Sophora tomentosa.* The source for most of these seed species is Arizona, USA except *Acacia visco* (La Rioja, Argentina) and *Acacia pruinocarpa* (Australia). One year old seedlings of each species were planted in the field, placed in holes (1x1x1m) containing a soil mix of 2 sand: 1 loamy soil. Tree or shrub seedlings were 3 m apart. There were total of 3 blocks and each block contained 10 species and 3 trees or shrubs from each species. The layout of the study was Randomized Complete Block Design (RCBD).

Chemical properties of the growing soil mixture were analyzed in the laboratory of the Department of Soil Science, College of Food and Agricultural Sciences, King Saud University (pH =7.7, Ec = 2.5 dS/m^{-1}, TDS = 1594 ppm).

All plant species were watered with well water (Ec = 3500 ppm) daily or twice a day at the hot season, using drip irrigation system. Each plant has 4 bubblers (4 liter/minute). The irrigation system was working for 10 minutes/ day. Thus, water requirement (40 liter) was provided for each plant. Mean maximum and minimum temperatures, and relative humidity were recorded during the study period (35°C, 20°C , 31.7%, respectively). Two months after planting, plant growth parameters were taken, and measured every two months for one year. Measured parameters included: plant height, stem diameter, number of branches, crown diameter, crown height, number of flowering branches and flowering period. Flowering rate % was determined by:

$$\frac{\text{Number of flowering branches}}{\text{Number of all branches}} \times 100$$

Other aesthetic characters such as leaf and flower colors were recorded during the study period. The species suitability for landscape uses were determined according to visual measurements (low- medium-high) based on the general species shape, growth habit and its own aesthetic properties. Data were analyzed by the analytical program (SAS), using the revised LSD test at 5% level of probability to compare the mean values.

3. Results and Discussion

The results showed variation in the plant growth characteristics among the various tree and shrub species during the study period.

Plant height:

Plant height increased throughout the study period, and so there were differences in plant height among all studied tree and shrub species (Fig.1). At the end of the study period, plant height of the tree species was the greatest in *Leucaena greggii* (4.64 m), while it was the lowest in *Acacia pruinocarpa* (2.41m) (Table 1). Some leuceana species such as *Leuceana greggii* form small to medium sized trees ranging from 3-5 m in height; however *L. greggii* develops in an erect manner, as the years go by, becomes a tree that is large in size and may reach 17 m in height (Hughes, 1998). *Acacia pruinocarpa* is an evergreen tree with green leaf color and reaches mature height of 9-12 m (Mitchell and Wilcox, 1994).

For the shrub species, plant height was the greatest in *Caesalpinia mexicana* (2.83 m) and the

lowest in *Sophora tomentosa* (1.07 m) (Table 1). *Caesalpinia mexicana* is a small evergreen tree or large shrub, reaching a height of 3-4.6 m and a spread of 1.8-3 m with bipinnately-compound dark green leaves (Irish, 2008). *Sophora tomentosa* is an evergreen shrub which has a moderate growth rate, high drought and salt tolerance and may reach 2-3 m height (Brown, 2009). The leaves of *Sophora tomentosa* are hairy and velvet and so they covered with a dense silky tomentose (matted hairs) that gives the plant its silvery cast (Gilman, 1999).

Stem diameter:

There are variations in the stem diameter values for the tree and shrub species (Fig. 2). At the end of the study period, the stem diameter value was the biggest in the tree species of *Acacia salicina* (10.90 cm) while it was the smallest in *Acacia visco* (7.60 cm). *Acacia salicina* is an erect fast growing tree, reaching 7-13 m in height and has a weeping habit and willow- like foliage (Cunningham, et al., 1981). El- Juhany (2003) found the stem diameter of the 16 old months unthinned trees of *Acacia salicina* about 6.89 cm and for the thinned trees about 13.42 cm. He indicated that stem diameter and height of *Acacia salicina* increased by 95% and 20% due to thining. Aref et al. (2006) reported that the stem diameter of *Acacia salicina* was 11.75cm. Al-Mefarrej and Elkhalifa (2006) in one- year field performance study found that *Acacia salicina* was the second best species as far as stem diameter.

Regarding the shrub species, stem diameter was the biggest in *Caesalpinia mexicana* (9.50 cm) and was the smallest in *Sophora tomentosa* (4.11cm) (Table1). *Caesalpinia mexicana* can be trained to grow with a short trunk and has medium current year stem or twig thickness (Gilman, 2007).

Number of branches:

The number of branches among the tree and shrub species were variable during the study period (Fig. 3). Number of branches of the tree species was the highest in *Acacia salicina* (24), while it was the lowest in *Acacia pruinocarpa* (17) (Table1). The number of branches reached 15.2 in *Acacia salicina* (Aref et al., 2006). Schuch and Norem (2004) reported that both *A. salicina* and *A. visco* have intermediate growth rates. They also observed that branch number of most studied species started to increase in March with no significant increases throughout June and small to no increases for the remainder of the year. *Acacia salicina* showed rapid increase in shoot elongation during the primary growing season and small increases in branch number from October to November. The shrubs number of branches was the highest in *Senna artemisioides* ssp. *filifolia* (43) and the lowest in *Sophora tomentosa* (10) (Table1).

Crown height and diameter

The greatest tree crown height and diameter were in *Acacia salicina* (3.94 m) and in *Leucaena greggii* (2.61 m) respectively, while the smallest values were in *Acacia pruinocarpa* (2.27 m), and in *Acacia visco* (2.03m), respectively (Table 1). For sandy soil, *Acacia salicina* was among other acacia species which show promise rapid growth and moderately long life spans, it can have a mean annual height increment of 1m/yr (Thomson, 1987). Among the shrub species, crown height and diameter were the greatest in *Caesalpinia mexicana* (2.63m) and in *Senna artemisioides* ssp. *Sturtii* (2.59 m), respectively; the lowest values were in *Sophora tomentosa* (0.97m), and in *Senna artemisioides* ssp. *artemisioides* (1.32m), respectively (Table1).

Flowering rate percentage

Both *Leucaena greggii* and *Acacia pruinocarpa* gave the highest flowering rate percentage (75%) in March. However, the flowering rate percentages were reduced in May and *Leucaena greggii* produced the highest percentage (44.4%) at the end of the study period (Fig.6). *Acacia salicina* produced (8.5%) in March and (11%) in May, and there was no appearing flowers on *Acacia visco*. The *Leucaena greggii* is large in size and reaches 17 m in height with a yellow colouring in the autumn (Hughes, 1998). *Acacia pruinocarpa*, commonly known as black gidgee, has flowers with yellow color and ball shape, which held in cylindrical clusters and bloom in the spring season (Mitchell and Wilcox, 1994). *Acacia visco* had no blooming during the study period. Schuch and Norem (2004) recorded in their study which lasted for three years, that flower buds and flowers for *A. visco* appeared in the second and third year during April and May, respectively for both years. It is reported that *Acacia visco* has fragrant yellow flowers in the spring (Rico-Arce, 2007).

Regarding the shrub species, all the three *Senna artemisioides* subspecies were blooming continuously, giving mass of one yellow color for ten months, and the highest flowering percentage (100%) occurred in Mach (Fig.7). It is known that these species produce an abundance of yellow flowers in winter and spring which are about 1.5 cm in diameter, followed by 2-7 cm long flat green pods which age to dark brown (Howes, 2009). *Senna artemisioides* ssp. *artemisioides* (Feathery cassia or Silver cassia) has small, yellow, pea-like, solitary flowers; bloom from December to May; boom is profuse, covering entire plant (Luckow, 1996). *Senna artemisioides* ssp. *sturtii* (Grey cassia) has bright yellow flowers in May- August, and bloom time through spring-summer- fall (Luckow, 1996). *Senna artemisioides* subspecies are adapted to a wide range of climatic conditions, although they are susceptible to frost, particularly when young, preferring dry, well drained sites with full sun. These species grow in round shape and have aesthetic characteristics which allow them to

be suitable for landscape uses (Luckow, 1996). However, at the end of the study period (in May), *Caesalpinia mexicana* produced the highest flowering percentage (92%), while it was (77%) in *Senna artemisioides* ssp. *filifolia* and (58%) in *Parkinsonia florida*. Gliman (2007) reported that *Caesalpinia mexicana* has yellow summer flowering and flowers cover the canopy for several months during the warm season. *Caesalpinia mexicana* has yellow, slightly fragrant flowers which are produced on 7.6-15.2 cm terminal spikes of 10-30, and blooming takes place from February to July, often continuing to October (Irish, 2008). *Senna artemisioides* ssp. *filifolia* (formerly *Cassia nemophila*) has yellow seasonal color in early spring and lemon yellow pea flowers in late winter to early spring at same time as *Senna artemisioides* ssp. *artemisioides,* but not fragrant, dark brown bean pod fruit in late spring to summer (Holman and Playford, 2000). *Parkinsonia florida* in this study produced the higest flowering rate percentage (69%) in March. *Parkinsonia florida* (syn. *Cercidium floridum*) has bright yellow, pea like blossoms which cover the plant in late spring (Larsen, 2004). The study showed the highest flowering rate percentage of *Sophora tomentosa* (61%) in May. *Sophora tomentosa* (Necklace pod) has bright yellow flowers which appear periodically throughout the year but most abundant in fall (Brown, 2009).

Although there were variations in plant growth characteristics of the studied tree and shrub species, generally they performed very well under the arid environmental conditions of Riyadh region.

Tree and shrub species aesthetic characters:

There were various aesthetic characters including leaf and flower colors, flowering period, flowering rate percentage, as well as the suitability for landscape uses among the different studied tree and shrub species (Table 2). The leaf color is green in all tree species while it is various among the different shrub species and sub-species (green-pale green-gray-gray green-silver). *Acacia salicina* tree has pale yellow flower color while both *Acacia pruinocarpa* and *Leucaena greggii* have yellow flower color. *Caesalpinia mexicana* has gold yellow flower color while all the other shrub species have yellow flower color. *Acacia visco* tree did not bloom during the entire study period; however the flowers of the other three tree species lasted for 6 months. The flowering period of *Caesalpinia mexicana* was 8 months while the flowering of the other shrub species lasted for 10 months. Among all tree species, *Leucaena greggii* has the greatest flowering percentage (44.4%) and the average of flowering branches percentage (47.8%). Among all the shrub species and subspecies, *Caesalpinia mexicana* has the greatest flowering percentage (92.1%), while *Senna artemisioides filifolia* has the greatest average percentage of flowering branches (60.4%). The suitability for landscape uses of both *Acacia salicina* and *Acacia pruinocarpa* tree species are high while it is medium for *Acacia visco* and *Leucaena greggii* trees. The *Acacia salicina* is serviceable, upright, accent tree, usually single or sometimes multiple trunk, which widely used in streetscape, medians, and as shade trees in residential and commercial landscapes (Schuch and Norem, 2004). This species showed high ability to improve microsite conditions and foster succession (Jeddi et al., 2009). *Acacia pruinocarpa* (black gidgee) grows as upright tree to 12 m high, and with a girth of up to 2 m, it has phyllodes rather than leaves which are a grey-green color, and has yellow flowers held in cylindrical clusters (Mitchell and Wilcox, 1994). Our results also showed that the suitability for landscape uses of the studied shrub species and subspecies were high except for *Sophora tomentosa* which was low. *Senna artemisioides* (*Cassia artemisioides*) is upright, rounded, feather shrub which produces an abundance of yellow flowers in winter and spring; its landscape value for long blooming period, best without pruning, needs space and effective in groups (Howes, 2009). Johnson (2004) reported that *Senna artemisioides* subsp. *filifolia* is widely grown as landscape plant in desert areas of southern and central Arizona. This species has been observed to establish occasionally along roads or in desert areas adjacent to landscapes where it is cultivated. The landscape value of *Senna artemisioides* subsp. *filifolia* is for its use as informal hedge, back ground, screen and accent shrub.

Table 1. Growth characters of the tree and shrub species at the end of the study period

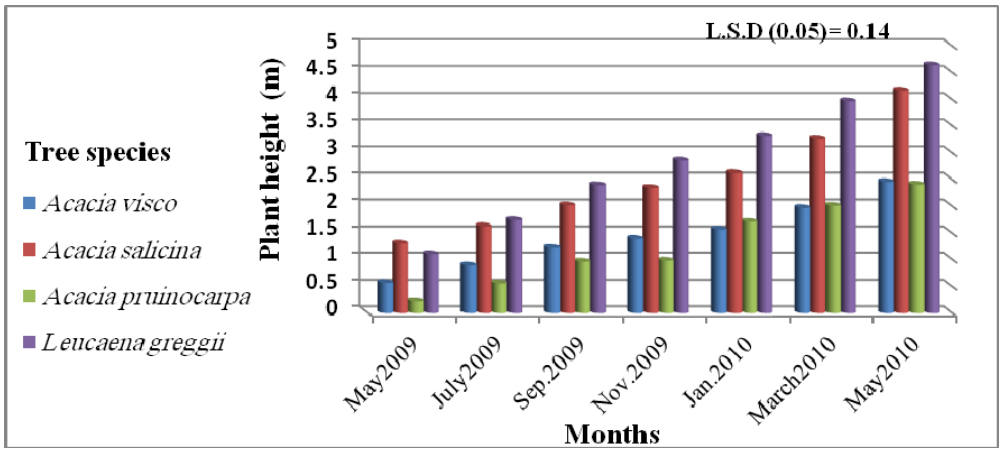
Tree species	Plant height (m)	Stem diameter (cm)	Number of branches	Crown heigt (m)	Crown diameter (m)
Acacia visco	2.46	7.60	17.2	2.29	2.03
Acacia salicina	41.7	10.90	24.1	3.94	2.34
Acacia pruinocarpa	2.41	8.50	16.8	2.27	2.24
Leucaena greggii	4.64	7.90	18.0	3.31	2.61
L.S.D (0.05)	0.14	0.21	1.3	0.27	0.22
Shrub species					
Caesalpinia mexicana	2.83	9.50	14.8	2.63	1.63
Parkinsonia florida	1.40	4.93	22.7	1.34	1.44
Senna artemisioides sturtii	2.40	5.40	27.7	2.33	2.59
Senna artemisioides artemisioides	1.51	5.20	24.9	1.33	1.32
Senna artemisioides filifolia	1.41	4.70	42.7	1.70	1.40
Sophora tomentosa	1.07	4.11	10.2	0.97	1.38
L.S.D (0.05)	0.09	0.24	2.1	0.54	0.38

Table 2. Some tree and shrub species aesthetic characters and their suitability for landscape uses

Tree species	Leaf Color	Flower Color	Flowering period (months)	Flowering rate* %	Suitability for Landscape Uses **
Acacia visco	Green	-	-	0	Medium
Acacia salicina	Green	Pale yellow	6	9.2	High
Acacia pruinocarpa	Green	Yellow	6	38.9	High
Leucaena greggii	Green	Yellow	6	47.8	Medium
Shrub species					
Caesalpinia mexicana	Green	Gold yellow	8	53.7	High
Parkinsonia florida	Pale blue green	Yellow	10	56.6	High
Senna artemisioides sturtii	Gray	Yellow	10	55.4	High
Senna artemisioides artemisioides	Silver	Yellow	10	58.9	High
Senna artemisioides filifolia	Green	Yellow	10	60.4	High
Sophora tomentosa	Gray green	Yellow	10	47.9	Low

* Average of flowering branches rate (%) during the study period.

** The species suitability for landscape uses were determined according to visual measurements (low-medium- height) based on shape, growth habit and its own aesthetic properties.



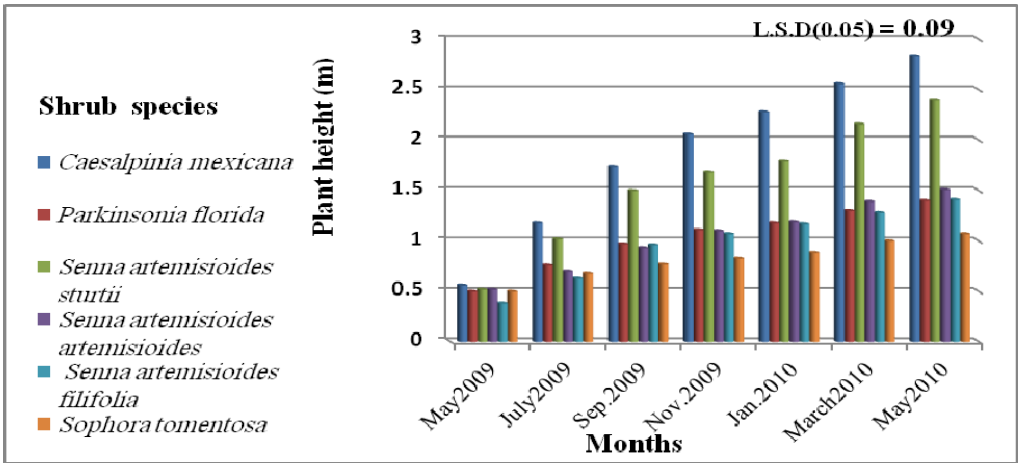


Fig. 1 Plant height of the tree and shrub species during the study period.

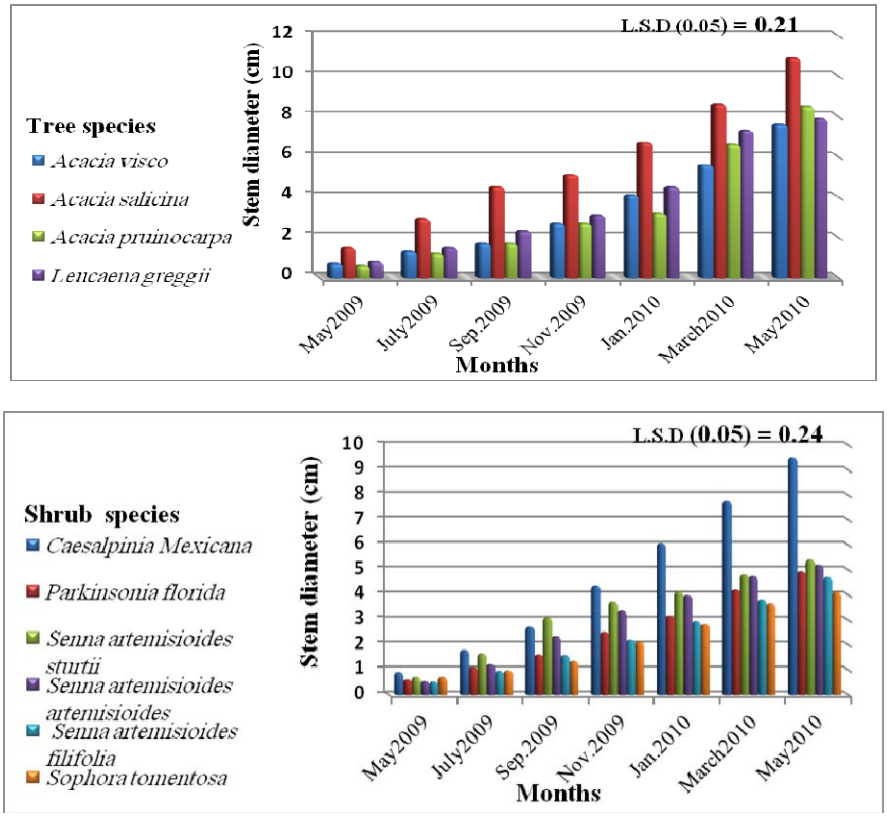
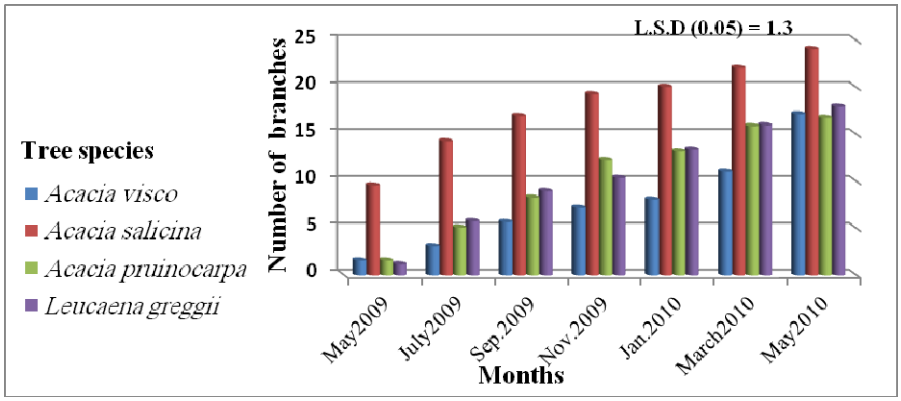


Fig.2 Stem diameter of the tree and shrub species during the study period.



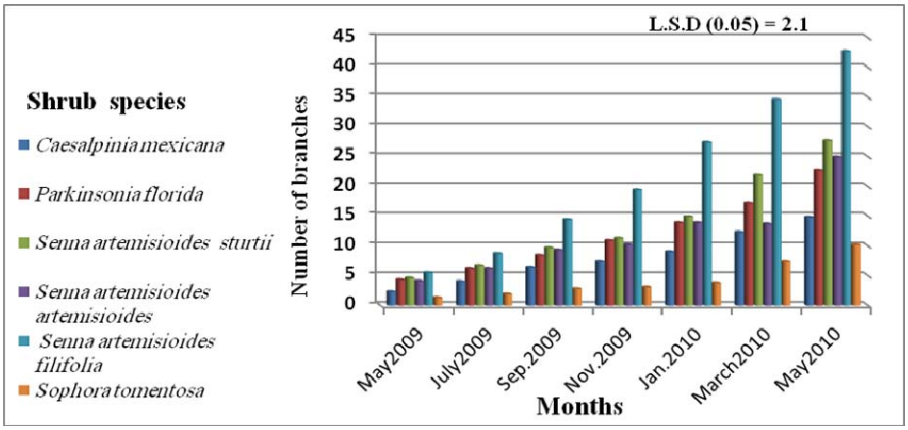


Fig. 3 Number of branches of the tree and shrub species during the study period.

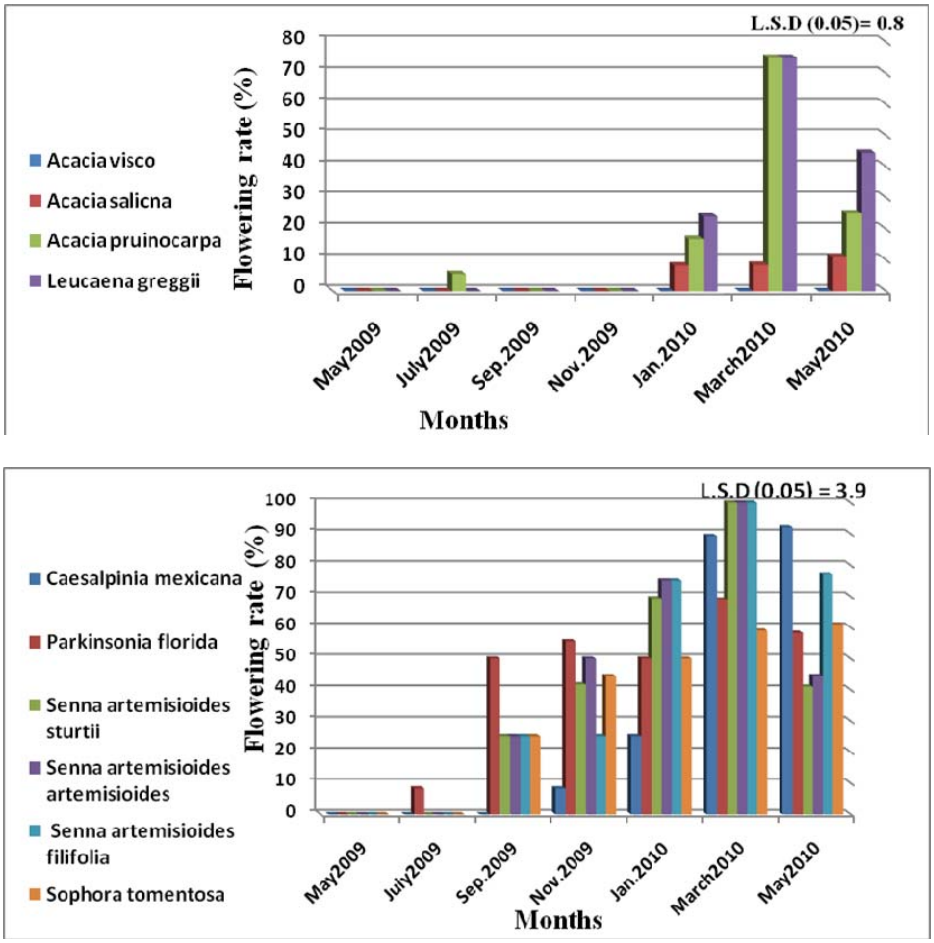


Fig. 4 Flowering rate (%) of the tree and shrub species during the study period

Conclusions

In conclusions, *Leucaena greggii* trees gave the highest values of plant height and crown diameter and had the greatest flowering rate percentage in March while *Acacia visco* gave the lowest stem diameter and crown diameter and had no blooming during the study period. *Acacia salicina* gave the highest values of stem diameter, number of branches and crown height while *Acacia pruinocarpa* gave the lowest plant height, crown height and number of branches; however it gave also the highest flowering percentage in March. *Caesalpinia mexicana* shrubs gave the highest values of plant height, crown height, and stem diameter while *Sophora tomentosa* gave the lowest plant height, crown height, stem diameter and number of branches. The subspecies of *Senna artemisioides*: sturtii, artemisioides and filifolia were blooming continuously, giving mass of uniform yellow color for ten months, and the highest flowering rate percentage occurred in March. They grow in round shape and have aesthetic characteristics which allow them to be suitable for landscape uses. The selected tree and shrub species vary in their characters and they performed very well under the arid environmental conditions of Riyadh region. In addition to the successful performance of the studied tree and shrub species, they had aesthetic values which made them suitable for various landscape uses under the environmental conditions of Riyadh region, Saudi Arabia.

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