



Evaluation of foliage potted plants for Northern plains

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ABSTRACT

Pollution is increasing at an alarming rate, especially in cities. The pollution may be air pollution (outdoor or indoor), noise pollution, water pollution or soil pollution which directly affects human health as well as work efficiency. In order to reduce air pollution indoor or outdoor, there is a great demand of potted plants. Plants help in reducing carbon dioxide, benzene and nitrogen dioxide levels, and also increase humidity and keep the temperature down. India is bestowed with different agro climatic conditions and evaluation of potted plants for their suitability for different agro climatic zones has not been done. Most foliage plants are tropical in nature and the movement of these plants to subtropical regions will affect their growth. Therefore, the present investigation was carried out during 2014–16 at Division of Floriculture and Landscaping, Indian Agricultural Research Institute, New Delhi to identify the plant species suitable for Delhi and Northern plains. For this purpose twelve species/varieties of different potted plants were used. The potted plants were kept under two conditions—glasshouse and open for the evaluation of growth and development. Based on different morphological traits like plant height, spread, number of branches, leaves and biomass, it was observed that plants like song of India, *Philodendron xanadu*, money plant, *Syngonium*, *Aglaonema*, Cardboard palm and Crotons were suitable for indoor conditions while Dragon tree, Areca palm, *Cordyline* and *Araucaria* were suitable for outdoor conditions. However, China palm was found best for both indoor and outdoor conditions under Northern plains.

Key words: *Dracaena*, Foliage plants, Indoor pollution, Money plant, Potted plants, *Syngonium*

Due to rapid increase in population the open space is decreasing and the place of individual houses has been taken over by skyscraping buildings. It is predicted that the present world population of ~7.3 billion will rise to ~9.7 billion by 2050, and that over the period the proportion of urban dwellers will increase from the current 54% to 60% (UNDESA 2015). The losses of greenspace and planted streetscapes (Chiesura 2004), the consolidation and densification of buildings (Abel 2010) and increased energy consumption, noise and air pollution will have significant negative environmental, social and health impacts. Earlier, indoor plants were used in commercial buildings for aesthetic and psychological purposes, but now it has become the necessity; as the population of metro cities spends more than 90 percent of their time indoors and air quality is often inferior to that outside (Jenkins *et al.* 1992) which will affect productivity and health negatively. Torpy *et al.* (2013) has demonstrated the effectiveness of potted plants in reducing all types of indoor air pollution. Therefore, in order to overcome such situation use of indoor plants is must. Since, most of the foliage plants production is done

under complete environment greenhouse regulation, and characterized by low irradiances but with a wide range for temperature, relative humidity and red/far red ratio (Blessington and Collins 1993). In India, pot plants are mainly produced in tropical region like Pune, Bangalore, Kolkata, Kadiyapulanka etc. and are supplied throughout the country but most of the times many plant species does not perform well under Northern plains due to adverse climatic conditions like heat wave, low temperature, low humidity and frost *etc.* Little or no work has been done on this aspect to find out the suitable potted plant species for Delhi and Northern plain conditions, therefore, present studies was planned and carried out with an objective of identifying the pot plants for their suitability for indoor and outdoor conditions of Northern plains.

MATERIALS AND METHODS

The present study was carried out at the Division of Floriculture and Landscaping, ICAR-Indian Agricultural Research Institute, New Delhi during the years 2014–16. Twelve potted plants of six families were evaluated for their suitability under North Indian plains (Table 1). These plants were procured from nursery during 2014–15 and were planted in 10 inch earthen pots using sand, soil, FYM (1:1:1) mixture. The standard cultural practices were used for the pot plant cultivation. Once the plants were established

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Table 1 Plants evaluated under indoor and outdoor conditions of Northern plains

Botanical Name	Common Name	Family
<i>Cordyline fruticosa</i> (L.) A.Chev	Ti plant/Good luck plant	Asparagaceae
<i>Dracaena fragrans</i> cv. Victoria (L.) Ker Gawl.	Dracaena/Song of India	Asparagaceae
<i>Dracaena reflexa</i> var. <i>angustifolia</i> Lam.	Dragon tree/Red edge dracaena	Asparagaceae
<i>Aglaonema commutatum</i> Schott.	Chinese evergreen	Araceae
<i>Philodendron xanadu</i> Croat, Mayo & J. Boos	Xanadu	Araceae
<i>Scindapsus aureus</i> (Linden & André) Engl.	Money plant	Araceae
<i>Syngonium podophyllum</i> Schott.	Arrowhead plant	Araceae
<i>Dypsis lutescens</i> (H. Wendl.) Beentje & J. Dransf.	Areca palm	Arecaceae
<i>Livistona chinensis</i> (Jacq.) R.Br. ex Mart.	China palm	Arecaceae
<i>Araucaria cookie</i> R.Br. ex Endl.	Cook pine	Araucariaceae
<i>Zamia furfuracea</i> L.f. ex Aiton	Cardboard palm	Zamiaceae
<i>Codiaeum variegatum</i> (L.) Rumph. ex A. Juss	Croton	Euphorbiaceae

properly, these were kept under glasshouse and open field conditions for the preliminary evaluation of growth and development. The experiment was laid out in Completely Randomized Block Design (CRD) with 12 plant species, 3 replications and 5 plants per replication. The average maximum temperature under glass house conditions varied from 21–46°C and average minimum temperature varied from 8–28°C while average maximum temperature under open conditions varied from 15–42°C and average minimum temperature varied from 3–25°C. Light measurements were carried out periodically during the growth stages under glass house and open field conditions, to monitor the actual light conditions to which the plants were exposed. All measurements were made on clear days at 10.00 am and 2.30 pm. The light intensity was measured by the digital lux meter (Extech 72 Instruments, 401025). The average light intensity varied from 27 to 63 Klx under open conditions and 13.7 to 25Klx under glasshouse conditions. Observations were made for different growth traits, viz. plant height (cm), plant spread (cm), number of fresh leaves, number of dried leaves and were counted at 2 months interval and were averaged to get the mean value. Greenness index was measured with Minolta chlorophyll meter (model SPAD 502) by averaging the 10–15 readings per plant as suggested by Wang *et al.* (2005). Observations were made for 2 years (2014–15 and 2015–16) and the data were pooled. Biomass traits, viz. fresh weight of stem (g), leaf (g), root (g), number of roots

and root length (cm), were recorded at the end of second year. For biomass observations the plants were uprooted, separated, washed and weighed. The data were subjected to analysis at 5% level of significance by using OPSTAT statistical software of Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana.

RESULTS AND DISCUSSION

Data related to vegetative traits have been presented in Table 2. Plant height ranged from 35.67 cm in China palm followed by *Dracaena*, *Aglaonema*, Crotons, *Cordyline*, *Philodendron* and maximum in areca palm (118.56 cm). A similar trend was also reported by Russ and Pertuit (2001) and Suryapriya *et al.* (2015) in various foliage plants like *Dracaena*, *Cordyline*, *Asparagus*, *Philodendron*, *Schefflera* and some indoor ferns. The plant spread varied from 20.36 cm in *Cordyline* under glasshouse and 21.00 cm under open conditions to maximum plant spread 111.67 cm in open and 95.93cm in glasshouse in areca palm. Similar variations for plant spread were observed by Eapen (2003) and Suryapriya *et al.* (2015). The maximum number of green leaves (44.19) under glass house conditions were found in *Zamia furfuracea* followed by *Scindapsus aureus* and *Philodendron xanadu*, however under open conditions maximum green leaves (42.96) were recorded in *Dracaena reflexa*. Maximum greenness index under glasshouse conditions was observed in *Philodendron xanadu* (69.76) followed by *Dracaena fragrans* cv. Victoria (61.63), however, under open conditions maximum greenness index was observed in *Dypsis lutescens* followed by *Zamia furfuracea*.

Comparison of attributes according to the family (Table 2) revealed that among the member of family Asparagaceae, *Cordyline* showed better growth under open conditions in terms of plant height (48.96 cm), plant spread (21.22 cm), maximum green leaves (8.52), minimum dry leaves (2.25) and maximum greenness index (43.19), however, *Dracaena fragrans* cv. Victoria resulted in maximum plant height (42.84 cm), plant spread (58.50 cm), maximum green leaves (18.70), minimum dry leaves (1.50) and maximum greenness index (61.63) under glass house conditions. On the contrary *Dracaena reflexa* showed maximum plant height (87.23 cm) and spread (53.74 cm), maximum green leaves (42.96), minimum dry leaves (1.82) and maximum greenness index (43.36) under open conditions.

Perusal of data related to the members of family Araceae reveals that *Aglaonema commutatum*, *Philodendron xanadu*, *Scindapsus aureus* and *Syngonium podophyllum* showed better growth in terms of plant height, plant spread, maximum green leaves, greenness index and minimum number of dry leaves under glass house conditions as compared to open (Table 2). Smith and Scarborough (1981) reported that many tropical foliage plants have low light intensity requirements in their native habitats. Similarly, Aasha (1986) reported that decreased light intensities increased plant height, leaf production, leaf area and greenness index in *Aglaonema*, *Aralia*, *Alocasia*, *Chlorophytum*, *Cordyline*, *Dieffenbachia*, *Dracaena*,

Table 2 Effect of growing conditions on vegetative traits of foliage potted plants

Species	Plant height (cm)		Plant spread (cm)		Number of green leaves		No. of dry leaves		Chlorophyll content	
	Green house	Open	Green house	Open	Green house	Open	Green house	Open	Green house	Open
<i>Cordyline fruticosa</i>	45.77	48.96	20.36	21.22	8.53	8.52	2.25	3.01	43.19	42.76
<i>Dracaena fragrans</i> cv. Victoria	42.84	31.20	58.50	35.85	18.70	12.28	1.50	5.23	61.63	60.57
<i>Dracaena marginata</i>	83.28	87.23	52.68	53.74	16.08	42.96	2.90	1.82	40.65	43.36
<i>Aglaonema commutatum</i>	52.00	43.08	45.30	26.98	24.90	7.56	4.48	5.17	43.19	20.76
<i>Philodendron xanadu</i>	46.72	26.48	61.34	46.02	38.45	21.72	1.58	3.29	69.76	56.21
<i>Scindapsis aureus</i>	83.88	42.55	49.86	18.11	40.00	12.00	4.34	3.08	46.40	34.06
<i>Syngonium podophyllum</i>	36.00	19.64	34.28	23.02	15.33	12.76	3.48	3.15	46.12	42.35
<i>Dypsis lutescens</i>	118.56	125.20	95.93	111.67	6.16	7.16	1.60	1.26	60.52	63.82
<i>Livistona chinensis</i>	35.67	36.96	49.27	50.36	5.97	5.37	2.25	2.15	50.93	49.63
<i>Araucaria cookii</i>	51.80	55.00	36.80	44.88	12.60	18.48	1.60	3.99	21.09	23.77
<i>Zamia furfuracea</i>	55.70	46.80	63.93	26.60	44.19	30.00	3.80	1.50	65.97	62.43
<i>Codiaeum variegatum</i>	48.70	31.00	20.70	16.20	34.30	18.70	3.17	11.40	38.32	15.00
CD (P=0.05)	10.88	6.64	9.53	9.88	7.29	7.82	1.62	3.36	5.93	4.27

Maranta, *Peperomia*, *Pleomele* and *Rhoeo*. Similar to our studies Alex (2012) also reported that *Scindapsus aureus* was best foliage species among the plants evaluated under indoor conditions. It performed well in all light levels as also reported by Davison (1998).

Among areca palm and China palm of family Arecaceae, maximum average plant height (125.20 cm), plant spread (111.67 cm), number of green leaves (7.16) and greenness index (63.82) was observed in areca palm under open conditions while maximum average plant height (36.96 cm), plant spread (49.27 cm), number of green leaves (5.97) and greenness index (50.93) was observed in China palm under glasshouse conditions. It was observed that plant species with larger leaves produce less number of leaves, whereas species with smaller leaves had greater number of leaves. This variation may be attributed to several factors like genetic make-up, partition of the photosynthates, production of more number of branches and tillers, etc. It is evident from the studies that the plants belonging to palm family performed better in open conditions as compared to indoors as they are native of dry areas where both temperature and light intensity is high. Our results confirmed the findings of Di Benedetto *et al.* (2006), Poole and Conover (1981) who reported that most foliage plants have their origins in the tropics and require high temperatures to sustain rapid growth.

Perusal of data presented in Table 2 shows that *Araucaria* showed maximum plant height (55.00 cm), spread (44.88 cm), number of green leaves (18.48) and greenness index (23.77) under open conditions. Cardboard palm (*Zamia* palm) showed better growth in terms of plant height (55.70 cm) and plant spread (63.93 cm), maximum green leaves (44.19), and greenness index (65.97) under glasshouse conditions as compared to open conditions (Table 2). Similarly growing crotons under glasshouse conditions

showed better results in terms of plant height (48.70 cm), and plant spread (20.70 cm), maximum green leaves (34.30), minimum dry leaves (3.17) and greenness index (38.32) as compared to open conditions. The better growth under glasshouse conditions can be attributed to low light intensity as compared to outdoor conditions. Similar to our studies Priessel *et al.* (1980) observed that *Codiaeum variegatum* var. *pictum* showed reduced chlorophyll and carotenoid contents with increased light intensity.

The data related to biomass attributes of foliage potted plants have been presented in Table 3. It is clear from the table that *Zamia furfuracea* showed maximum stem weight under greenhouse (133.75 g), whereas, *Dypsis lutescens* recorded maximum stem weight (116.78 g) under open condition. *Aglaonema commutatum* showed maximum leaf weight (144.48 g) under greenhouse however, it was found to be at par with stem weight (125.40 g) of *Zamia furfuracea*. Leaf weight of *Syngonium podophyllum* was significantly higher (114.50 g) in open environment. Data with respect to shoot weight indicate *Zamia furfuracea* attained maximum shoot weight (259.15 g) under greenhouse whereas, *Dypsis lutescens* showed higher shoot weight (231.28 g) under open conditions compared to other foliage potted plants. From the above results it can be said that *Zamia furfuracea* performed better in greenhouse conditions than other species, whereas, *Dypsis lutescens* under open conditions with respect to stem weight, leaf weight and shoot weight. Studies carried out by Di Benedetto *et al.* (2006) suggests that the distribution of biomass among plant organs is not fixed and is affected by environment, plant habit, life span and the interactions among these factors. To support our findings, Abhay *et al.* (2015) reported that plants of *Dracaena fragrans* grown under shade nets exhibited better plant height, leaf number, leaf greenness index, biomass and

Table 3 Effect of growing conditions on biomass attributes of foliage potted plants

Species	Stem wt. (g)		Leaf wt (g)		Shoot wt.		Root length (cm)		Root wt. (g)		Root no.		Shoot:root ratio	
	GH	O	GH	O	GH	O	GH	O	GH	O	GH	O	GH	O
<i>Cordyline fruticosa</i>	19.68	38.44	14.82	31.78	34.50	70.22	22.00	35.48	12.02	18.90	24.85	10.50	2.82	3.72
<i>Dracaena fragrans</i> cv. <i>Victoria</i>	74.88	19.08	102.26	25.80	177.14	44.88	32.40	26.00	57.38	42.74	13.75	26.80	3.09	1.05
<i>Dracaena marginata</i>	47.88	67.28	24.40	33.96	72.28	101.24	35.50	29.80	108.23	68.18	17.25	14.22	0.67	1.48
<i>Aglaonema commutatum</i>	75.75	47.22	144.48	96.12	230.23	143.34	58.02	22.20	81.55	55.46	57.25	70.74	2.82	2.58
<i>Philodendron xanadu</i>	47.88	8.75	30.25	17.36	78.13	26.11	41.50	29.20	34.53	23.58	8.50	17.22	2.26	1.11
<i>Scindapsus aureus</i>	35.68	16.96	22.43	18.32	58.11	35.28	46.80	34.00	31.08	24.00	17.50	31.78	1.52	1.47
<i>Syngonium podophyllum</i>	14.95	16.46	30.13	28.34	45.08	44.80	69.13	44.00	30.60	20.54	13.25	17.50	1.47	2.18
<i>Dypsis lutescens</i>	76.18	116.78	73.18	114.50	149.36	231.28	45.25	22.40	193.65	118.00	37.00	48.06	0.77	1.96
<i>Livistona chinensis</i>	22.35	19.08	26.50	24.68	48.85	43.76	27.00	22.00	31.95	29.18	11.50	17.66	1.52	1.50
<i>Araucaria cookii</i>	47.22	76.30	51.94	90.08	99.16	165.38	69.58	55.40	58.40	72.40	5.00	17.22	1.70	2.29
<i>Zamia furfuracea</i>	133.75	85.76	125.40	70.02	259.15	155.78	0.00	0.00	46.06	30.85	28.50	14.22	5.63	5.05
<i>Codiaeum variegatum</i>	17.03	16.46	38.48	12.72	55.51	29.18	18.00	13.66	13.75	13.28	7.55	5.00	4.03	2.19
CD (P=0.05)	21.96	33.59	59.87	20.13	43.32	25.04	12.15	8.80	25.58	15.92	4.40	33.07	0.76	1.00

GH, Green house condition; O, Open condition

harvest index as compared to open conditions. Maximum production of photosynthates in zamia plants due to their ability to grow under protected environment even though they are sun loving plants. However, results with respect to performance of *Dypsis lutescens* is quite interesting as it has the ability to grow well in open conditions also.

Data related to root parameters exhibited that *Araucaria cookii* performed well recording maximum root length under both greenhouse (69.58 cm) and open (55.40 cm) conditions. Root weight was significantly maximum (193.65 g in greenhouse and 118.00g in open conditions) in *Dypsis lutescens*. *Aglaonema commutatum* recorded highest number of roots in both greenhouse (57.25) and open (70.74) environment. However, root number of *aglaonema* was found at par with *Dypsis lutescens*. Shoot to root ratio was recorded highest in *Zamia furfuracea* under both open (5.63) and greenhouse (5.05) environment, whereas minimum was found in *Dracaena reflexa* (0.67) in greenhouse and *Dracaena fragrans* cv. *Victoria* (1.05) in open environment. Optimum shoot to root ratio indicates utilization of available resources for the production of photo assimilates hence, biomass. *Zamia furfuracea* recorded maximum shoot to root ratio under both conditions might be attributed to better absorption of available nutrients and water from the soil. The increased production of food will lead to vigorous shoots in terms of weight and length, thereby makes the roots more vigorous to maintain proper root to shoot ratio. Higher proportion of roots in *Aglaonema commutatum* indicates its ability to compete for soil nutrients. Large proportions of shoot production are characteristic of vegetation in early vegetative phases, while high proportions of root production are characteristic of climax vegetative phases.

Comparison among the members of family Asparagaceae revealed that *Cordyline* showed better growth under open

conditions in terms of stem weight (38.44g), leaf weight and shoot weight, root parameters, viz. root length, root no. and root weight. The maximum shoot:root ratio (3.72) for *cordyline* was observed under open conditions. Comparison of both the *Dracaena* species shows that *Dracaena fragrans* cv. *Victoria* exhibited better growth in terms of shoot and root parameters under glasshouse conditions with maximum shoot : root ratio (3.09), while *Dracaena reflexa* showed maximum biomass for shoot and root under open conditions with maximum shoot : root ratio (1.48) under open conditions. Due to better root parameters the plants were able to uptake the maximum nutrient and water content to the shoot and leaves and thus resulting in healthy plants under respective conditions. Similarly, Abhay *et al.* (2015) reported that plants of *Dracaena fragrans* grown under shade nets exhibited better plant height, leaf number, leaf greenness index, biomass and harvest index as compared to open conditions.

Perusal of data related to the members of family Araceae reveals that *Aglaonema*, *Philodendron xanadu* and *Scindapsus aureus* showed maximum biomass in terms of shoot and root parameters under glasshouse conditions. Similarly, Di Benedetto and Cogliatti (1990) reported that the higher the light intensity results in greater increment in shoot dry weight. Moreover, these species are susceptible to frost conditions, therefore, could not perform better under open conditions as compared to indoors. In family Araceae, *Syngonium* and *Araucaria cookii* resulted in maximum shoot : root ratio (2.18 and 2.29 respectively), under open conditions as compared to glasshouse.

Comparison of two palm species, i.e. China palm and areca palm showed that maximum leaf weight (114.50 g), stem weight (116.78 g), shoot weight (231.28 g) root length (45.25 cm) and shoot : root ratio (1.96) in areca palm was

observed under open condition, while China palm showed almost similar shoot root ratio both in glasshouse (1.52) and under open conditions (1.50).

Comparison of *Araucaria* under both the conditions revealed that growing *Araucaria* under open conditions resulted in maximum leaf weight (90.08g), stem weight (76.30 g), shoot weight (165.38), and shoot root ratio (2.29). It is clear from Table 3 that *Zamia furfuracea* showed better results for root and shoot growth under glasshouse conditions. Growing of *Codium variegatum* under glasshouse showed better shoot and root growth with 4.03 S/R ratio.

From the present study, it is concluded that in north Indian plains species like *Dracaena relexa*, areca palm, *Cordyline* and *Araucaria* are suitable plants for outdoor conditions, while song of India, *Philodendron xanadu*, money plant, *Syngonium*, cardboard palm, crotons and *Aglaonema* are suitable for indoor conditions, however China palm can be grown successfully both in indoor and outdoor conditions.

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