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Ranchana P
Assistant Professor, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India

Mangaiyarkarasi R
Assistant Professor, Imayam Institute of Agriculture and Technology, Tiruchirappalli, Tamil Nadu, India

Baranidharan R
Ph.D. Scholar's, Department of Floriculture and Landscaping, TNAU, Coimbatore, Tamil Nadu, India

Mirunalini SP
Ph.D. Scholar's, Department of Floriculture and Landscaping, TNAU, Coimbatore, Tamil Nadu, India

Arunkumar M
Ph.D. Scholar's, Department of Floriculture and Landscaping, TNAU, Coimbatore, Tamil Nadu, India

Corresponding Author:
Ranchana P
Assistant Professor, Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu, India

Role of shrubs in saline ecosystem: A review

Ranchana P, Mangaiyarkarasi R, Baranidharan R, Mirunalini SP and Arunkumar M

Abstract
In the Floriculture industry apart from cultivation of loose flowers and cut flowers, the landscape gardening industry is a fast emerging and an innovative industry. In landscaping, plant components play a major role to make it more creative. Of these plants, ornamental shrubs play a key role in landscaping. Shrubs are the most diverse group of ornamentals grown in gardens. It may be defined as a perennial plant having many woody branches arising from the base of the plant while their upper shoots are soft. The growth habit of the shrubs is generally erect and bushy, attaining a height of 0.5 to 4 meters, while some shrubs grow prostrate in habit. They vary widely in stature and include dwarf bushes to those attaining the stature of small trees. It forms an integral and major part in landscaping. Any indoor or outdoor garden is incomplete without a shrub. Hence, ornamental landscaping is a commercially important element of the floriculture industry.

Keywords: Landscaping, shrubs, APTI, uses, saline

Introduction
Shrubs are the most diverse group of ornamentals grown in gardens. In habit they are hardy perennials having low spreading woody branches. They vary widely in stature and include dwarf bushes to those attaining the stature of small trees. Aesthetic and functional uses of shrubs refer to the shrubs grown for decorative purposes with certain utility in the garden. Shrubs grown for aesthetic features include those having attractive foliage, flowers, fruit, stem, bark etc. Shrubs that are ever flowering and have spectacular flowers are grown as focal point plants. Shrubs are grown to provide permanent colour along with annuals that refer to mixed borders. Shrubs that have small leaves, closely spaced branches and prone to pruning are used as hedge plants (George, 2009) [16]. Other than aesthetic and functional uses, the ornamental value of a shrub is decided based on scoring their aesthetic quality. Aesthetic quality index (AQI) is a visual observation based on scoring visual quality parameters. This index is not expressed by any units but by the dimensionless numbers. Aesthetic quality index values are useful in selecting ornamental plants for landscaping. Air pollution can be defined as the introduction of particulate matter or biological materials into the atmosphere that cause harm or discomfort to humans and other living organisms and thereby damage the environment. The plant species which are more sensitive to this environment act as biological indicators of air pollution. Plants' response to air pollutants can be learned at physiological and biochemical levels by examining the factors which deliberate resistance and susceptibility. That analysis is nothing but the Air Pollution Tolerance Index (APTI). It can be determined by deriving the values for four different biochemical parameters *i.e.* ascorbic acid, leaf extract pH, relative water contents and total chlorophyll respectively.

Hence, calculation of Air Pollution Tolerance Index (APTI) will be useful while selecting shrubs for an industrial area or traffic islands and also calculation of Aesthetic quality index will be useful in easy selection of plants for landscaping (Singh and Rao, 1983) [44].

Classification of shrubs
Shrubs are classified (Randhawa and Mukhopadhyay, 1986) [34] into three groups according to their requirement of sunlight under tropical conditions. Most of the tropical flowering shrubs grow best in full sun and their flowering is affected if not exposed to morning bright sun. They are listed below.

a) Based on light requirement (Randhawa and Mukhopadyay, 1986) [34]
Shrubs requiring full sun: Shrubs of this category can grow under high light intensities.

Example: *Codiaeum* spp.

Shrubs requiring semi-shade

Shrubs of this category can grow under medium light intensities.

Example: *Beloperone amherstiae*, *Excoecaria bicolor*, *Pentas lanceolata*

Shrubs requiring both semi-shade and sun

Shrubs of this category can be grown under both high light intensity and medium light intensity.

Example: *Acalypha* spp., *Crossandra* spp., *Eranthemum* spp., *Mussaenda erythrophylla*,
Thunbergia erecta, *Cestrum* spp.

b) Based on horticulture point of view (Randhawa and Mukhopadyay, 1986) [34].

Shrubs are also classified based on the horticultural point of view as

1. Ornamental foliage shrubs
2. Flowering shrubs
3. Shrubs bearing attractive berries

Ornamental foliage shrubs

Ornamental foliage shrubs are grown and valued for their attractive foliage characters.

Example: *Codiaeum* spp., *Eranthemum* spp., *Cordyline* spp. (George, 2009) [16].

Flowering shrubs

The shrubs that are grown and valued for their beautiful and attractive flowers then those shrubs are called as flowering shrubs.

Example: *Hibiscus rosasinensis*, *Tecoma stans* (George, 2009) [16].

Shrubs bearing attractive berries

Apart from flowers and foliage some shrubs are grown for their attractive berries and those plants are called berry bearing shrubs.

Example: *Ochna squarrosa*, *Ochna wightiana*, *Duranta* spp., *Rauwolfia canescens*
(Bose and Chowdury, 1991) [8], *Fortunella japonica* **(**Randhawa and Mukhopadyay, 1986) [34].

c) Based on stature (George, 2009) [16]

Arboreal shrubs

Arboreal or tree-like shrubs are more than 2.5 to 3m tall and attain woody nature and branching habit of small trees.

Example: *Murraya exotica*, *Ixora* spp., *Tabernaemontana coronaria*.

Bushy shrubs: Bushy shrubs attain a maximum height of 1 to 2m and an equally wide crown spread.

Example: *Hibiscus rosa sinensis*, *Gardenia jasminoides*.

Sub-shrubs

Sub-shrubs are low growing or dwarf shrubs attaining a maximum height below 1m.

Example: *Cuphea* spp., *Galphimia* spp.

Characteristic feature of shrubs

Morphological characters are the physical form and external structure of the plants, which are useful in visual identification of the plants. Morphological characters of plants can be compared, measured, counted and described to assess the differences or similarities in plants and can be further used for plant identification, classification and descriptions.

Morphological characters are of two types *viz*., Quantitative characters and Qualitative characters. Quantitative characters can be counted and measured which includes plant height, plant spread, leaf length, leaf breadth, internodal length, petiole girth and petiole length. Qualitative characters are morphological features which include leaf shape, leaf colour, leaf margin, leaf pubescence, leaf texture, leaf base and leaf tip.

Kent *et al*. (2007) [19] described the morphological characters of *B. spectabilis*,
B. glabra, *B. peruviana* and *Bougainvillea* hybrids. Bougainvillea is a shrubby vine and multi-trunked. *Bougainvillea spectabilis* is well distinguished for its hairy leaves and stems. The leaves are large and ovate, with rippling along the edges and hairs on underside. The bracts are red, dark pink or purple. Its prickles are large and may be bent. The growth habit is dense and colourful bracts appear up and down the branches.

Assaf *et al*. (2009) [5] observed the leaf characters of *Eranthemum nervosum* and found that the leaves were ovate to ovate lanceolate with entire margin, simple, exstipulate, decurrent bases and acuminate apices. The upper surface of the leaf is dark green in colour while the lower one is paler. The petiole is short in the upper leaves and long in lower ones.

The leaf morphological diversity in croton *C. variegatum* was studied by Mollick *et al*. (2011) [28]. In case of all quantitative parameters, the phenotypic variations were observed irrespective of all croton cultivars. Leaf length varied from 12.7-26.4 cm; width varied from 2.5-12.3 cm; leaf middle width is 0.2-11.3 cm; leaf upper quarter width is 2.2-11.3 cm; leaf down quarter width is 2.2-7.9 cm; petiole length was 1.3–9.8 cm; leaf area was 30.8-209.8 cm^2.

Seeruttun and Sanmukhiya (2013) [40] used 12 morphological characters like height, growth habit, petal colour, flower shape, flower form, diameter of flower, length of staminal column, and length of corolla, length of adult leaf, width of adult leaf, leaf shape and length of petiole to characterize seven *Hibiscus* species. It has been observed that in *Hibiscus rosa-sinensis* height ranged from 4.7±0.4 m with a shrubby growth habit, reflexed flower shape ranged from single petalled, elliptical leaf shape with rounded tip, diameter of flower ranged from 15.6 ± 0.4 cm, length of staminal column was 6.4 ± 0.3 cm, length of corolla was 8.6±0.3 cm, length of an adult leaf was 7.5 ± 1.6 cm, width of adult leaf was 6.2±1.5 cm, length of petiole was 5±1.1 cm.

The karyomorphological analysis in different varieties of the plant *Tabernaemontana coronaria* has been conducted by (Samanta *et al*., 2015) [36]. They observed that the petiole length ranged from 1.5 mm in the variety Dwarf to 7.3 mm in 'Variegata' variety of this species. The internode length did not vary to a large extent except in Dwarf variety. Leaf area ranged from 0.62 to 9.03 cm^2 in case of small leaves, from 0.83 to 16.37 cm^2 in case of medium leaves, and from 1.02 to 30.50 cm^2 in case of large leaves.

Special characters of shrubs

In addition to aesthetic and functional uses, certain special characters like air pollution tolerance index, fragrance, butterfly attraction and aesthetic quality index are also taken into consideration while categorising the shrubs.

a) Air Pollution Tolerance Index

The rapid growth of urban population both natural and through migration, has put heavy pressure on air quality of urban areas through increase in industrial sectors. Air pollution has attained an increasing trend due to the alarming usage of automobiles. It degraded the air quality in major metropolitan cities of India. Hence the research work was initiated by several workers all over the world to mitigate the pollution. One among the ways is using plants as a control measure.

The best way to mitigate the pollution using plants as a tool is The Air pollution tolerance index. It can be evaluated by different parameters *viz*., leaf extract pH, relative water content of the leaf, ascorbic acid and total chlorophyll content. Hence, this index helps to identify the location whether it shows tolerance or sensitivity to air pollutant level.

Agrawal *et al*. (1991) [3] studied 25 plant species near and around a state highway. The plants were subject to analysis of biochemical parameters such as leaf pH, total water content, total chlorophyll and ascorbic acid. The APTI values studied among the 25 plant species revealed that 8 plants were found to be sensitive and 8 were intermediate tolerant and 9 were found to be tolerant in that area.

Kalyani and Singaracharya (1995) [17] grouped plants into convenient groups based on the APTI values of the plants as tolerant (30-100), intermediate (17-29), sensitive (1-16) and very sensitive (<1).

The sensitivity and resistance of plants around a brick kiln towards the pollution stress was studied by Dwivedi and Tripathi (2007) [12]. The leaf samples were collected around kilns and APTI value was determined and found that at less polluted sites the APTI value was less. The plants with higher APTI value which were considered to be resistant species were present at most of the sites and they acted as bio-accumulators in the reported sites. This study concluded that resistant plants with higher APTI can be employed for mitigation and control of air pollution.

Liu and Ding (2008) [26] concluded that the APTIs of most of the shrubs were higher than those of trees, which indicated that shrubs in general were more tolerant to air pollution than trees. Change in sampling period resulted in change in the tolerance gradation of APTI of species. Air pollution tolerance was also affected by natural climate conditions such as temperature and humidity.

Among twenty-four species evaluated for APTI, only four tree species such as *Ficus religiosa* (25.77), *Zizyphus jujuba* (22.32), *Phyllanthus emblica* (18.88) and *Cassia fistula* (18.69) showed moderate response by changing their biochemical characters (Lakshmi *et al*., 2008) [24]. These four species can serve as indicators of industrial air pollution.

Agbaire and Esiefarienrhe (2009) [2] reported that out of six plant species selected around Otrogun gas plant, three species namely *Emilia Santifolia*, *Manihot esculenta* and *Elaesis guineensis* were the more tolerant species since they had the least percentage increase in APTI values. An overview of the entire result obtained revealed that different plants respond differently to air pollution; hence the different indices it was observed that plants growing in apparently polluted environments have higher APTI than less from less polluted environments.

Das and Presad (2010) [10] studied the Air Pollution Tolerance Index of twenty common plant species comprising 14 trees and 6 shrubs, grown in and around Rourkela steel plant. It has been found that species ranked as tolerant are moderately tolerant are considered as ideal plant species for landscaping in vicinity of polluting industry were *Acacia mangium*, *Swietenia mahagoni*, *Anthocephalus indicus*, *Caesalpinia pulcherrima* and *Grevillea robusta*. Species ranked as sensitive, such as *Albizia lebbeck*, *Alstonia scholaris*, *Artocarpus integrifolia*, *Azadirachta indica*, *Bauhinia variegata*, *Bougainvillea spectabilis*, *Cassia siamea*, *Lagerstroemia speciosa*, *Lantana camara*, *Mangifera indica*, *Pongamia pinnata*, *Syzygium cumini*, *Tabernaemontana coronaria*, *Thevetia neriifolia* and *Ziziphus jujuba* have to be avoided.

Gharge and Geetha (2012) [15] reported that out of four annual herbs evaluated for APTI *Amaranthus spinosus* was found to be the most tolerant, followed by *Eclipta alba*, *Alternanthera sessilis* and *Chenopodium album*. They concluded that plants with higher value of Air Pollution Tolerance Index were known to be tolerant species in the pollutant habitat.

A Study area consisting of 27 species was selected around a cement factory located within a radius of 6 km. The plants were chosen from five different areas around the factory such as in and around the factory, within 2 km radius of the factory, 2-4 km away from the factory and 4-6 km away and 10-12 km (control zone) away from the factory. Plants were collected from each zone thrice a week. The outcome of the study was reported by Radhapriya *et al*. (2012) [32]. All the species surrounding the cement industry showed high pollution concentration when compared to the control. Generations of new trees were reduced in the polluted area when compared to non-polluted zones and also various factors would have led to this condition. The trees which were located around the factory showed more tolerance when compared to other species. This study suggested that highly tolerant, moderately tolerant and intermediately tolerant species will be suitable for an effective green belt around the cement industry.

Enete *et al*. (2012) [13] evaluated five species of streetscape shrubs for their tolerance level to air pollution. It had been observed that the air pollution tolerance index ranged from 10.60 to 14.32 with *Ixora* Red having the highest APTI value and Yellow Bush with lowest APTI value and sensitive ones can be utilized as bioindicators of the air quality, while those species in the tolerant group can be used for development of streetscape greening.

A study was conducted using the leaf samples of 12 species of trees collected from the area near roadsides of a railway junction and near roads of a residential area by Krishnaveni *et al*. (2014) [20]. It has been concluded that the tolerance index for the area near roadsides of railway junction were in decreasing order as follows: *Syzygium cumini* < *Azadirachta indica*< *Ficus carica*< *Ficus religiosa*< *Mangifera indica*< *Pongamia pinnata*< *Annona squamosa*< *Albizia saman*< *Pithecellobium dulce*< *Polyalthia longifolia*< *Tamarindus indica*< *Ficus benghalensis*. The APTI for the area near roadsides of residential areas were in increasing order as follows:

Tamarindus indica> *Mangifera indica*> *Syzygium cumini*> *Azadirachta indica*>

Annona squamosa> *Albizia saman*>*Pithecellobium dulce*> *Ficus carica*>
Polyalthia longifolia> *Pongamia pinnata*> *Ficus religiosa*> *Ficus benghalensis*.

Fifteen plant species were evaluated for Air Pollution Tolerance Index, namely *Albizia amara*, *Mangifera indica*, *Citrus aurantiaca*, *Psidium guajava*, *Holoptelea integrifolia*, *Delonix regia*, *Bambusa tulda*, *Morinda pubescens*, *Azadirachta indica*, *Millettia pinnata*, *Wrightia tinctoria*, *Eucalyptus tereticornis*, *Delonix elata*, *Manilkara zapota* and *Tetelia* spp. It was found that all the plants assessed were found to be sensitive as it has APTI values in the range of 1-16 and concluded that APTI is not an independent factor as it is influenced by the combination of parameters like pH, relative water content, ascorbic acid, chlorophyll (Krishnaveni *et al*., 2015) [21].

Thirty ornamental flowering shrubs growing under tropical climatic conditions were evaluated for their Air pollution tolerance index (APTI) values by Naduthodi and Bawoor (2015) [30]. They grouped shrubs into tall (above 2 m height), medium (1-2 m height) and dwarf groups (height below 1 m) based on their manageable height, to compare within their respective groups. APTI value was the maximum for
Calliandra haematocephala and the minimum for *Hamelia patens* among the tall shrubs, while APTI value was the maximum for *Clerodendrum macrosiphon* and the minimum for *Pseuderanthemum reticulatum* in case of medium group shrubs. Among the dwarf shrubs APTI value was the maximum for *Ixora rosea* and the minimum for *Allamanda cathartica* 'Dwarf'.

Sowmiya *et al*. (2017) [46] found that the shrubs under tall and medium growing category have shown a tolerant range of APTI values. The APTI of tall growing shrubs in decreasing order is as follows: *Bauhinia tomentosa*> *Caesalpinia pulcherrima*> *Ixora chinensis*> *Nerium oleander*> *Pseuderanthemum reticulatum*> *Eranthemum albo-marginatum*>
Mussaenda erythrophylla> *Hibiscus rosa-sinensis*> *Tabernaemontana coronaria*> *Acalypha hispida*> *Jatropha panduraefolia*> *Rondeletia odorata*> *Eranthemum bicolor*>
Bougainvillea spectabilis> *Murraya exotica*. The APTI of medium growing shrubs in decreasing order is as follows: *Ruellia simplex*> *Galphimia gracilis* > *Tecomaria capensis*> *Phyllanthus nivosus*> *Pentas lanceolate*> *Graptophyllum pictum*> *Plumbago auriculata*> *Barleria cristata*> *Turnera ulmifolia*> *Calliandra haematocephala*> *Plectranthus scutellarioides*> *Codiaeum variegatum*> *Hamelia patens*> *Leucophyllum frutescens*> *Polyscia balfouriana*. Hence these could be suggested for the landscaping in polluted areas like roadside, industries, congested residential areas etc.

b) Aesthetic quality index

Aesthetic quality index is a visual observation, expressed by dimensionless numbers and is useful in selecting ornamental plants for landscaping. Scoring of shrubs based on visual quality has been reported by some workers.

Plant quality grade in poinsettia was evaluated after 30 days in an interior environment using a classification ranging from 1 (poor) to 5 (excellent) (Wang and Blessington, 1990) [50].

Duc *et al* (2000) studied three cultivars of boxwood *Buxus microphylla B. sinica* and *B. sempervirens*. The aesthetic qualities were evaluated by visual rating using a scale of 0–9: appearance (9 - no appreciable defect, 7 - some foliage discoloration due to summer sun scald or winter bronzing, 5 - 50% of plant alive, and 0 - dead); winter colour
(9 - green, 5 - reddish brown, and 0 - brown/gray brown); and bronzing (9 - no bronzing, 5 - 50% of foliage bronzed, and 0 - all foliage bronzed).

In some bedding plants, the evaluation grade considered the plant wilt status with a classification from 1 to 5, where 5 - completely turgid, 4 - soft to the touch, 3 - starting to wilt, 2 - wilted with complete loss of turgor, 1 - wilted to the point that leaves were dry and brittle (Waterland *et al*., 2010).

Banon *et al*. (2011) studied the visual quality of *Lantana camara* and
Polygala myrtifolia. The ratings of visual quality index ranged from 1 (non-commercial) to 5 (very good quality) based on the amount of leaf discoloration, leaf necrosis, defoliation and flowering.

Lubell (2013) evaluated the landscape suitability of six underused shrubs and compared them to the exotic shrub species and rated for the different characters like bushiness, foliage colour and pest incidence. Then the plants have been rated by three different observers and then the cumulative value has been taken into consideration. The aesthetic quality index for the six shrubs was also calculated and found that Buttonbush, sweet fern, and sweet gale had aesthetic quality index (AQI) ratings similar to controls. Northern bush honeysuckle and American filbert took long time to establish and got AQI ratings similar to controls.

Sowmiya *et al*. (2017) [46] found that the highest Aesthetic Quality Index (8.3) of tall growing shrubs was given for the shrub *Rondeletia odorata* and in case of medium growing shrubs it was 8.0 given for the shrub *Pentas lanceolata*. Hence, the plants with the highest aesthetic quality index could be given more preference and used in landscaping. Aesthetic Quality Index for the shrubs taken for study ranged from 4.3-8.3.

Uses of shrubs in landscaping

a) Aesthetic and functional uses of shrubs

Shrubs grown for decorative purposes will have attractive plant characters. Other than the decorative purposes, shrubs also have some special characteristics like fragrance which provide different functional uses in gardens. The utility and importance of shrubs in a garden varies. The following are some of the aesthetic and functional uses of shrubs in landscaping.

b) Focal point plants

It is the element which draw attention into the garden. Shrubs that grow tall and are ever flowering may be grown as the focus of attention in the lawn or rockery (Trivedi, 1996).

Sowmiya *et al*. (2017) [46] experimented with tall and medium growing shrubs and in her study, she found that among the tall growing shrubs *Bauhinia tomentosa*, *Hibiscus rosa-sinensis*, *Ixora chinensis*, *Murraya exotica*, *Mussaenda erythrophylla* and *Tabernaemontana coronaria* were categorized under focal point plants because these shrubs grew taller between the range of 1 m to 2 m, had larger attractive leaves with ranging from 5-13 cm along with bushy and dense growth habit. The dense canopy of these shrubs could be attributed to their leaf arrangement and shape, which was round, irregular, and semi-circular. In the same way, among the different medium growing shrubs, *Barleria cristata*, *Calliandra* *haematocephala*, *Hamelia patens* and *Tecomaria capensis* have been categorized under focal point, because these five shrubs grew taller upto 1m and were bushy and dense in growth habit. They also had attractive foliage.

c) Shrub border/ Shrub group

Group of shrubs when planted along the border and separates two distinct areas of a garden or grown collectively in a corner is called shrub border. In the shrub border it could be a mixture of deciduous and evergreen shrubs planted along the borders. A mass of many shrubs on the border with the property will help to create a backdrop for flower border (George, 2009) [16].

The shrubs *Acalypha hispida*, *Bauhinia tomentosa*, *Bougainvillea spectabilis*, *Caesalpinia pulcherrima*, *Eranthemum albo-marginatum, Eranthemum bicolor*, *Hibiscus rosa-sinensis*, *Ixora chinensis*, *Mussaenda erythrophylla*, *Nerium oleander*, *Pseuderanthemum reticulatum* and *Rondeletia odorata* were grouped under shrub border/ shrub group because they mix well with other shrub species, whereas the foliage characters of *Eranthemum albo-marginatum*, *Eranthemum bicolor* and *Pseuderanthemum reticulatum* were variegated. The variegation observed was green with yellow and green with white and these shrubs could be used only in a shrub border to break the green coloured monotony. They do not mix well for shrub group due to their variegated foliage (Sowmiya *et al*., 2017) [46].

d) Topiary

The art or practice of clipping shrubs or trees into ornamental shapes is topiary. These methods may be geometrical or abstract such as columnar, globe or pyramid. They may represent birds, larger animals, living statues or just decorative objects and architectural features. Shrubs that are grown for their foliage and can withstand heavy pruning can be used for topiary making (George, 2009) [16].

The tall growing shrubs that could be used for topiary are *Bougainvillea spectabilis* and *Murraya exotica* and the medium growing shrubs *viz*., *Barleria cristata*, *Hamelia patens*, *Leucophyllum frutescens*, *Phyllanthus nivosus*, *Plumbago auriculata* and *Tecomaria capensis* were found best under topiary group (Sowmiya *et al*., 2017) [46].

e) Foundation planting

The foundation planting is a combination of the entrance planting, the corner planting and a transition area that joins them. As a unit these plantings should lead the eye toward the front door and welcome the visitor. Low-growing shrubs can be grown as foundation-covers to mask the visible basement area of buildings. They also serve as transition plantings between the indoor and outdoor garden areas (George, 2009) [16].

The foliage character of the shrubs categorized under foundation planting were larger in size *i.e*., leaf length ranged from 7.5-13 cm and some smaller in size *i.e*. leaf length of *Acalypha hispida* was 5.85 cm. Large leaved shrubs with less number of leaves and small leaved shrubs with more number of leaves fit this category very well and also the plants used must be darker in colour, have larger leaves and have closer branching habit.

Sowmiya *et al*. (2017) [46] conducted an experiment on shrubs and she noticed that the shrub *Acalypha hispida* has dark brown coloured leaves, while *Bougainvillea spectabilis* has closer branching habit and *Ixora chinensis* has larger leaves which could be useful in masking the basement area of the building. Among the medium growing shrubs, the shrubs *Barleria cristata, Plectranthus scutellarioides*, *Leucophyllum frutescens*, *Pentas lanceolata*, *Turnera ulmifolia* and *Tecomaria capensis* were characterized under foundation planting group. Among these shrubs, *Barleria cristata*, *Plectranthus scutellarioides*, *Pentas lanceolata* and *Turnera ulmifolia* were low growing to a height of 0.5-1.4m. Though the shrubs *Leucophyllum frutescens* and *Tecomaria capensis* grew to a medium height (1.15 and 1.30 m), they could be pruned and maintained low and hence can be used as foundation plants.

f) Screening

Shrubs that have small leaves and closely spaced branches, which can be frequently pruned to get fine surface texture, make excellent foliage hedges, having the tendency to grow taller, hardy (having thorns) (George, 2009) [16]. The evergreen screening is used either to form a dense hedge either bushy from the ground upwards or as full standards shrubs.

The medium growing shrubs *viz*., *Calliandra haematocephala*, *Codiaeum variegatum*, *Hamelia patens*, *Leucophyllum frutescens*, *Polyscia balfouriana* and *Tecomaria capensis* can withstand heavy pruning were suitable for imparting screening effect. The shrub *Hamelia patens* with closer branching habit and medium number of leaves per branch also fit into this category (Sowmiya *et al*., 2017) [46].

g) Fragrance garden

The fragrance garden is a sensory experience, full of fragrant flowers and aromatic leaves. Shrubs which produce strong fragrant flowers can be grouped together to produce a masking fragrance effect to the garden. Shrubs suitable for this type of garden must produce fragrant flowers (Trivedi, 1996).

Sowmiya *et al*. (2017) [46] experimented with tall and medium growing shrubs and in her study, she found that among the all tall growing and medium growing shrubs, *Murraya exotica* alone had fragrant flowers. This shrub could be planted in a group alone or mixed with other fragrant flowers for fragrant gardens. Though the *Nerium oleander* flowers were mild in fragrance, they were not considered for this category.

h) Butterfly garden

Butterfly gardens are designed to create an environment that attracts butterflies as well as certain moths. Butterfly gardens are often aimed at inviting butterflies to feed on the flower nectar and to lay eggs as well. Butterflies are always attracted to flowers. There are some flowering shrubs to which butterflies are attracted. Shrubs of that type are grouped together to attract groups of butterflies at one place. Sowmiya *et al*. (2017) [46] identified the shrubs suited for butterfly gardens as given below.

Table Butterfly garden

S. No.	Butterflies' species	Shrubs visited
Tall growing shrubs		
1.	*Hebomoia glaucippe* (Great orange tip)	*Ixora chinensis*
2.	*Papilio demoleus* (Lime butterfly)	*Ixora chinensis, Rondeletia odorata*
3.	*Catopsillia pomonai* (Common emigrant)	*Murraya exotica*
4.	*Delias eucharis* (Common jezebel)	
5.	*Euploea core* (Common crow)	*Murraya exotica, Pseuderanthemum reticulatum*
6.	*Pachliopta hector* (Crimson rose)	*Murraya exotica, Rondeletia odorata*
7.	*Graphium Agamemnon* (Tailed jay)	*Nerium oleander, Pseuderanthemum reticulatum*
8.	*Tirumala limniace* (Blue tiger)	*Pseuderanthemum reticulatum, Rondeletia odorata*
9.	*Danaus chrysippus* (Plain tiger)	*Pseuderanthemum reticulatum*
10.	*Pacliopta aristolochiae* (Common rose)	
11.	*Hypolimnas misippus* (Danaid egg fly)	
12.	*Papilio polytes* (Common mormon)	*Rondeletia odorata*
Medium growing shrubs		
13.	*Hypolimnas misippus* (Danaid egg fly)	*Barleria cristata*
14.	*Papilio demoleus* (Lime butterfly)	
15.	*Euploea core* (Common crow)	*Pentas lanceolate*

i) Rock garden

Rockery is a mound or bank built of earth and stones and planted with rock plants. It is also known as the alpine garden. The standard layout for a rock garden consists of a pile of aesthetically arranged rocks in different sizes, with small gaps between which plants are rooted. Shrubs that are hardy and grow dwarf can be used in rock gardens
(Randhawa and Mukhopadyay, 1986) [34].

The shrubs *viz*., *Barleria cristata*, *Leucophyllum frutescens*, *Phyllanthus nivosus*, *Ruellia simplex*, *Turnera ulmifolia* and *Polyscia balfouriana* are hardy and dwarf and are found suitable for rock garden as suggested by Sowmiya *et al*. (2017) [46]. Moreover, in the same study, it was suggested that the shrubs *viz*., *Bougainvillea spectabilis* and *Leucophyllum frutescens* were also identified as the best plant for above purpose.

j) Moon garden

Moon gardens are so designed to make it possible to enjoy them at night, even without artificial lights. There are basically four types of plants used in moon gardens. They are plants with white flowers, plants with bright foliage, night bloomers and plants with fragrant flowers. Group planting of shrubs bearing white flowers, done in clumps, therefore can enhance the charm is called moon garden (Jindal, 1970).

k) Mechanisms of salt stress resistance

These mechanisms are characterized as avoidance and tolerance. The term “salt resistance” has been used referring to a combination of tolerance and avoidance strategies (Levitt, 1980). Mechanisms of salt avoidance include delayed maturity until favorable conditions prevail; the exclusion of salts at the root zone or preferential root growth into non-saline areas; compartmentalization of salt and secretion from specialized organelles such as salt glands and salt hairs; or storage in older leaves.

Yeo and Flowers (1984) summarized several salt tolerance mechanisms as below.

- **Salt exclusion:** Plants do not take up excess salt by ion selective absorption, such as Na^+ exclusion as genetic differences in Na^+ exclusion are highly correlated with differences in salinity tolerance.
- **Salt reabsorption:** Tolerant plant genotypes absorb excess salt but it is reabsorbed from the xylem and Na^+ is not translocated into the shoot.
- **Root-shoot translocation:** Salinity tolerance is associated with a high electrolyte content in the roots and lower content in shoot.
- **Leaf to leaf compartmentation:** Excess salts are transported from younger to older leaves. Plants effectively localize salts in non-functional old leaves.
- **Tissue tolerance:** Plants absorb salt but in properly compartmentalized vacuoles within the leaves in order to lower the harmful effects on plant growth.
- **Dilution effect:** Plant takes up salt but it gets diluted by faster growth rate and high-water content in shoots.

Tolerant varieties may have one or two of the mechanisms said above but not all. Among the tolerance mechanisms, the synthesis of compatible solutes and control of ion uptake have been considered effective.

Effect of salt stress for shrubs growth

Wang *et al*. (2001) [51] opined that abiotic stress causes a sequence of physiological, morphological and biochemical changes which impact on plant growth and productivity.

Salinity, oxidative stress, drought and extreme temperatures are drought, salinity, extreme temperatures, and oxidative stress are often interrelated and may bring analogous cellular damage. Salinity enforces a range of stresses on plant tissues. Two of these are osmotic stress which results from the relatively high soil solute concentrations and ion cytotoxicity.

The rate of leaf growth was decreased with increase in soil salinity conditions. This occurs due to the osmotic effect of the salt around the roots, which deters plant water uptake and causes leaf cells to lose water. However, this loss of cell volume and turgor is transient and reductions in cell elongation and also cell division lead to slower leaf appearance and smaller final size over the longer term (Munns and Tester 2008).

Salinity decreased calendula plant growth significantly. Growth reduction under saline conditions has been well documented in various plants by many authors (Senaratna *et al*., 2000; Alpaslan and Gunes, 2001; Kaya *et al*., 2003; Sivritepe *et al*., 2003; Turan and Aydın, 2005). Munns (2002) indicated that reduction of plant growth under saline conditions may either be due to reduced availability of water or to the venomousness of sodium chloride.

Wahome (2003) reported that plants may lose some sections of their shoots under such conditions. Under high salinity conditions, plant growth and dry matter partitioning were significantly subdued. Ravindran *et al*., (2007) evaluated halophytes to study the ability to reduce salinity in the upper 40 cm of soil, which revealed that sodium absorption ratio gradually declined up to 67 per cent in natural saline soils cultivated with *Clerodendrum inerme*.

Clerodendrum inerme withstands salinity up to the limit of 22 dSm^{-1} (Dagar and Singh, 2007) [9] *C. inerme* has the characteristics of both true mangroves and mangrove associates (Wang *et al*., 2010) [52]. Irrigation water salinity has been reported to cause a quadratic reduction of the dry biomass of shoots, dry biomass of stems and height of plants (Fraga *et al*., 2010).

A study carried out in *Clerodendrum inerme* by Silambarasan and Natarajan, 2012, revealed that NaCl had positively affected the growth of the seedlings by decreasing shoot length and root length with increasing salinity. The survival of seedlings to NaCl salinity was 500 mM.

Proline accumulation is important for osmotic adjustments under abiotic stress conditions and it is believed that high levels of proline can be beneficial to stressed plants. The shrub *Leucophyllum frutescens* produced more proline under salinity conditions and it was found that it can tolerate the saline ecosystem (Kathari *et al*., 2016).

Soluble protein is generally decreased in response to salinity. It has also been reported that high salt concentration either causes an increase in the N-contents and high protein content in some glycophytic plants or increase in soluble proteins (Shaddad *et al*., 2005 and Kathari *et al*., 2016).

The up-regulation of catalase activity is considered to be an adaptive response to overcome any potential damage to leaf tissues by preventing the accumulation of toxic levels of H2O2 produced during metabolism. These findings are in accordance with the observations of Pandey *et al*. (2014), Abd Allatif *et al*. (2015) and Kathari *et al*. (2016) in Leucophyllum.

The accumulation of these NaCl ions to harmful levels, as well as the general osmotic growth inhibition, contributes to the reduction in tree growth and fruit yield. Different cultivars and rootstocks absorb chloride and sodium at different rates, so tolerance can vary considerably within a speci es (Nirit Bernstein *et al*., 2001).

An experiment was conducted by Kathari *et al*. (2016), at higher salt level (54 dS m-1), the shrub *Leucophyllum frutescens* recorded higher potassium (K) content which imparts salinity tolerance.

Bohnert and Jensen (1996) identified that several genes played their roles to impart tolerance to increased NaCl and at the same time certain proteins were also involved for the same. Differential patterns in protein changes were observed between tolerant and susceptible plants on the polyacrylamide gels, based on presence or absence bands at 30 kDa. The presence of proteins at 30kDa may have a role in tolerance response. Absence or presence of some bands may also indicate a functional involvement in stress response. This could be considered as a key point in protein pattern changes either in tolerant or susceptible plants. It is believed that stress induced proteins allow plants to make biochemical and structural adjustment that enable them to cope with the stress conditions (Ricard *et al*., 1996).

Protein profiling by SDS-PAGE provides new evidence on resistance in salinity condition. Biochemical genetic markers such as SDS-PAGE were substantially involved in drought and salinity stresses (Rahman *et al*., 2007). In the experiment conducted by Kathari *et al*. (2016), it was found that a protein band of 30 kDa was observed in the shrubs *viz*., *Leucophyllum frutescens* and *Clerodendrum inerme* respectively. They were identified as salt tolerant types.

Categorization of shrubs for year-round flowering

Shrubs express a varied season of flowering and also interval of flower production. The tall growing shrubs *viz*., *Hibiscus rosa-sinensis*, *Hibiscus schizopetalus*, *Hibiscus syriacus*, *Iochroma tubulosum*, *Jacobinia carnea*, *Jacobinia pauciflora*, *Kopsia fruticosa*, *Malvaviscus arboreus*, *Mussaenda erythrophylla*, *Nerium oleander*, *Ochna kirkii*, *Osmanthus fragrans*, *Pogonopus exsertus*. *Reinwardtia trigyna*, *Ruellia rosea*, *Ruttya fruticosa*, *Solanum macranthum*, *Streptosolen jamesoni*, *Tarenna zeylancia*, *Tecoma gaudichaudi*, were identified as year-round flowering. Similarly, in medium growing shrubs category, *Calliandra brevipes*, *Calliandra houstonii*, *Calliandra tweedii*, *Angelonia grandiflora*, *Cassia glauca*, *Cestrum nocturnum*, *Crossandra undulaefolia*, *Eranthemum laxiflorum*, *Gustavia insigns*, *Hamelia patens*, *Tecomaria capensis*, *Turnera ulmifolia*, *Vinca rosea* and *Wedelia trilobata* were identified as year-round flowering (Kannan *et al*., 2017). Apart from this, the list given below will give the details of the season of flowering of certain shrubs that can be planted together to give a blooming effect throughout the year in the garden (Sowmiya *et al*., 2017) [46].

Shrub groups for year-round flowering

Shrub groups for year-round flowering
Tall growing shrubs
a) *Caesalpinia pulcherrima* (Oct-July) + *Ixora chinensis* (Jan-Mar, July-Sep)
b) *Jatropha pandura folia* (Feb-Oct) + *Bauhinia tomentosa* (Nov-Mar)
c) *Bougainvillea spectabilis* (Nov-July) + *Tabernaemontana coronaria* (Feb-Sep)
d) *Tabernaemontana coronaria* (Feb-Sep) + *Bauhinia tomentosa* (Nov-Mar)
e) *Murraya exotica* (Jan, May, Jun, Oct, Nov) + *Tabernaemontana coronaria* (Feb-Sep)
f) *Murraya exotica* (Jan, May, Jun, Oct, Nov) + *Jatropha panduraefolia* (Feb-Oct)
g) *Eranthemum bicolor* (Mar-May) +*Rondeletia odorata* (Dec-Jan, May-Aug) + *Pseuderanthemum reticulatum* (July-Aug, Dec-Feb)
h) *Ixora chinensis* (Jan-Mar, July-Sep) + *Eranthemum albo-marginatum* (Feb-July) + *Caesalpinia pulcherrima* (Oct-July)
i) *Rondeletia odorata* Dec-Jan, May-Aug) + *Eranthemum albo-marginatum* (Feb-July) + *Eranthemum bicolor* (Mar-May)
Medium growing shrubs
a) *Hamelia patens* (Aug-May) + *Ruellia simplex* (May-July, Nov-Jan)
b) *Phyllanthus nivosus* (Feb-Oct) + *Ruellia simplex* (May-July, Nov-Jan)
c) *Pentas lanceolate* (July-Oct, Jan-Apr) + *Ruellia simplex* (May-July, Nov-Jan)
d) *Barleria cristata* (Sep-Mar) + *Phyllanthus nivosus* (Feb-Oct), *Graptophyllum pictum* (Nov-May) + *Phyllanthus nivosus*(Feb-Oct)

Conclusion

Aesthetic part of Horticulture is Landscaping. In which the shrubs play an extensive insignificant role to beautify a land in terms of both foliage and flowering types as hedges, cut greens, shrubbery border, combat pollution, improve aesthetic quality index, focal point, imparts fragrance and screening effect in the garden. Likewise, it also finds its place in special gardens *viz*., moon garden, fragrance garden, rock garden, butterfly garden, etc. It possesses a wide range of colours as flowers and foliage that invites butterflies and other insects which fulfil the principle of gardening is movement. Additionally, it is also found suitable for planting under a saline ecosystem where the plants generally find difficult to grow and produce flowers. As well as, certain types of shrubs can be planted together as a stretch in a border line to give the effect of continuous flowering throughout the year which is in different colours and helps to break the monotony of the garden when the people visit the garden in different time intervals. It makes the garden create an unexampled blissful place, serene and tranquil atmosphere, and so on. This is how the shrubs play a tremendous role in the garden both in aesthetic and functional utility even in saline ecosystems as well.

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