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Growth characteristics and post trimming regrowth potential of tropical and sub-tropical landscape hedge plants in response to spacing

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ABSTRACT

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Spacing of landscape plants is one of the factors determining the outcome of a design in terms of canopy formation which is one of the variables for aesthetic appearance in terms of shapes and forms. This study was conducted between September 2016 and September 2017, to determine the appropriate intra-row spacing for five plant species in hedge formation. The plant species used were *Duranta erecta*, *Hamelia patens*, *Ficus retusa*, *Buxus sempervirens* and *Acalypha wilkesiana*. Transplanting was done at intra-row spacing of 30, 40, 50 and 60cm and a constant inter-row spacing of 100cm. The experiment was a Randomized Complete Block Design in split plot arrangement with three replicates. Plant height, number of leaves, number of branches and canopy space, as indices of species suitability for use as hedge, were measured fortnightly. Plant regrowth and aesthetic characteristics were assessed after periodic trimming. *H. patens* and *B. sempervirens* species had the tallest plants. *B. sempervirens* and *D. erecta* produced the highest number of leaves while *D. erecta* and *H. patens* had the highest number of branches. *D. erecta* had significantly ($p<0.05$) the fastest post-trimming shoot regrowth rate relative to other species following the 1st and 2nd trimming (25 and 28 WAT respectively). The effect of spacing on shoot regrowth length was significant after the 3rd, 4th and 5th trimmings (31, 34 and 37 WAT respectively). The highest shoot regrowth height was recorded at 40cm spacing followed by 30cm intra row spacing. All species responded best at 50cm intra-row spacing for the number of branches and canopy space as well as early hedge formation. The study concluded that *B. sempervirens* was suitable for ideal hedging at 40cm intra-row spacing while *A. wilkiesiana* and *H. patens* were only suitable as informal hedges. Hence,

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B. sempervirens species is recommended as the ideal hedge plant choice based on its early regrowth after trimming, high leaf and branch production as well as overall speed in hedge formation at 31WAT.

Keywords: Ornamental plants, Aesthetic value, intra-row spacing, shoot regrowth height, Shoot regrowth rate, Hedge formation

INTRODUCTION

Hedges are an important and ubiquitous element of many public, commercial and residential landscapes (Kendal 2008). Hedge plants are mostly made of a number of shrubs, but at times could be trees or shrublets usually of similar species, planted closely together in a line. It could be a continuous line of shrubs in which the individuality of each plant is lost (Hessayon 2008, Mitra 2013). Brun and Dinius (2015) defined hedges as closely spread linear strips of vegetation that perform a variety of valuable functions in an urban environment.

Hedges are the most utilitarian plantings in the landscapes and can be used in many ways for different purposes. A neat, thrifty hedge is a thing of beauty that directs movement within the landscape, while the pruned portion could be useful as food for man and animal. A hedge can also serve as an attractive background for other plantings, as a low ornamental border in front of shrub groups, or as an edging around formal floral beds. Blanusa et al (2019) reported that hedges provided a number of important ecosystem services including microclimate alteration, flood and pollution mitigation and biodiversity provision, along with some disservices which are invasiveness and allergenicity. Motivations to plant urban hedges vary, but they are usually introduced to mark boundaries between properties, or public and private spaces. They are largely associated with enclosing private gardens, but hedges may also be used in the public domain as perimeters of parks, along street corridors and around municipal or industrial buildings (Blanusa et al 2019).

Kendal et al (2008) reported that hedges are generally the preferred landscaping treatment in public and private landscapes (Smardon 1988, Palmer 1989, Todorova et al 2004, Kendal et al 2008). Studies, however, are yet to provide guidance as to preference or relative suitability of plant species as hedges. It is essential for landscape designers and horticulturists to possess adequate knowledge of ornamental plants for their proper selection and utilization within various landscapes.

Spacing of ornamental plants makes the difference between a well-groomed yard and an overgrown jungle. Plants spaced too far apart make the landscape look barren and unattractive and may never form desired hedges. Use of narrow spacing for hedge plant establishment could lead to overcrowding, growth retardation, increased disease problems and cost. However, hedge plants must be appropriately spaced such that they are able to form a fully dense screen and create the desired attractive appearance within a short period. There is dearth of information on appropriate spacing of plants for hedging and this sometimes seems to create confusion because one cannot uniformly recommend across species and all sites how far apart plants should be placed (Rothenberger 1996). Therefore, knowledge of appropriate spacing is necessary to get the maximum effect from the minimum number of plants. This study was done to assess the response of some hedge plants under different spacing with a view to recommend appropriate spacing for early formation of a dense hedge as a factor of aesthetics determination for each species. The aesthetics in landscape is defined as the satisfaction of an individual with the landscape (Yilmaz et al 2021). According to Lang (1994) and Yilmaz (2021), aesthetics are hidden in the clues provided by the designer, not in the eyes of the beholder. Thus, how to combine plants to provide aesthetic satisfaction and how the aesthetics of a designed landscape can be analyzed are important issues.

METHODOLOGY

Description of the Study Site

The research was conducted at Federal University of Agriculture, Alabata Road, Abeokuta (7°15'N, 3°25'E) Ogun State, South Western Nigeria, between September 2016 and September 2017. The study area is characterized by a tropical climate with distinct wet and dry seasons with bimodal rainfall pattern and mean annual air temperature of about 30^{0}C. An annual rainfall of 1146.30mm and 819.60mm was recorded for 2016 and 2017, respectively, but 390.3mm and 727.40mm occurred respectively during the experiment in both years (Table 1). From the site survey and the land use history of the site, it was observed that the site was left fallow for two years and the previous crops that were cultivated on the site include cassava and maize. The predominant vegetation found on the site were: *Tridax procubens, Imperata cylindrica, Eupatorium odoratum, Euphorbia hirta, Euphorbia heterophylla, Mariscus alternifolius, Fluerya ovalifolia, Fluerya aestuans* and *Acroceras zizanioides.* The soil of the study area was sandy loam with pH of 7.23. It was low in organic matter (0.8%) with 0.1% of total Nitrogen, 42mg kg^{-1} available Phosphorus and 0.34, 4.95 and 1.06cmol kg^{-1} of Potassium, Calcium and Magnessium respectively. Meteorological data for the experimental site were collected from the Meteorological Station of Water Resources Management and Agro Meteorology Department, Federal University of Agriculture, Abeokuta.

Land Preparation

The site for the experiment was ploughed and harrowed, followed by manual removal of unburied plant debris to enhance cleanliness and soil tilth. Poultry manure (layer birds) sourced from the university farm (battery cage system) was applied at a rate of 5t ha^{-1} two weeks before transplanting.

Plant Species Selection

Plant selection were based on selection criteria for hedge species mentioned by Hitchmough (1994) that have: (1) the ability to tolerate trimming (2) high shoot density, (3) relatively small leaves and (4) the ability to form quickly then grow slowly. The selected species were *Duranta erecta*, (Yellow duranta as common name) *Hamelia patense* (Fireworks), *Buxus. Sempervirens* (*West Indies*), *Acalypha wilkiesiana* (red acalypha) and *Ficus retusa* (Yellow ficus) (Figure 1). They are evergreen shrubs, well adapted to tropical and sub-tropical environments and widely grown as hedge plants in South Western Nigeria.

Table1. Meteorological data during the period of the experiment (2016 - 2017)

Parameter	Rainfall (mm)		Maximum Temperature (°C)		Minimum Temperature (°C)		Sunshine (hr)	
Months	2016	2017	2016	2017	2016	2017	2016	2017
January	32.00	15.90	35.40	35.30	20.70	22.40	4.00	4.40
February	0.00	0.00	36.40	36.40	24.20	23.90	3.30	4.20
March	150.30	34.30	34.80	35.80	24.40	24.20	2.00	6.10
April	68.20	112.80	34.20	33.40	24.40	23.70	6.30	5.60
May	226.20	146.00	33.50	32.40	24.30	23.10	5.10	5.20
June	150.50	121.80	30.60	31.40	22.70	23.70	4.00	6.10
July	65.20	156.10	29.70	29.20	23.00	22.80	2.80	2.10
August	63.60	90.50	28.90	28.18	22.70	22.43	1.95	1.28
September	229.00	50.00	30.50	30.02	23.60	22.12	2.70	2.11
October	155.40	92.20	32.30	31.94	22.60	27.78	4.90	4.16
November	5.90	Na	32.70	Na	23.50	Na	5.50	Na
December	0.00	0.00	35.30	34.86	22.50	21.61	5.50	4.23
Total (rainfall)	1146.30	819.60						
Mean (temperature)			32.86	32.63	23.22	21.52	4.00	4.13

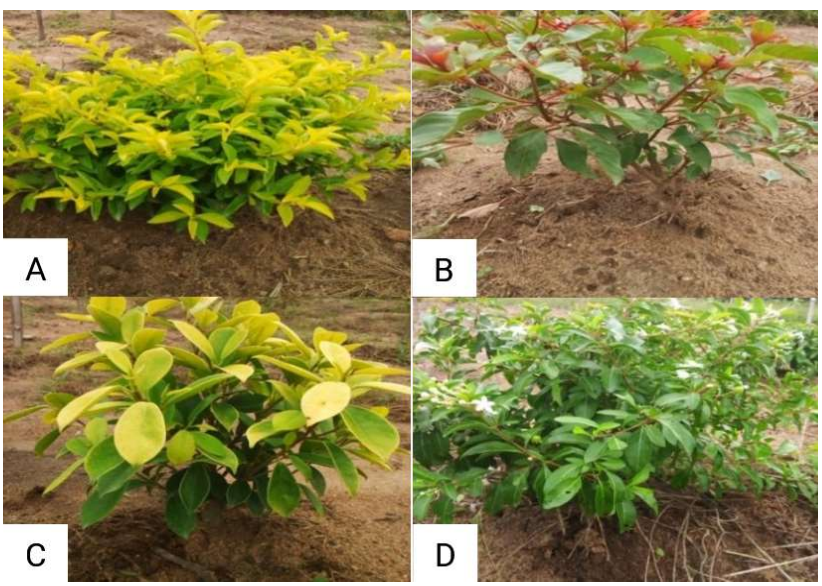

Figure 1. Selected plant species (A) *Duranta erecta* (B) *Hamelia patens* (C) *Ficus retusa* (D) *Buxus sempervirens* (E) *Acalypha wilkesiana* as captured on the experimental field

Figure 1. continued

Experimental Design and Treatments

The field trial was a 5x4 factorial arrangement in a split plot fitted into a Randomized Complete Block Design (RCBD) with three replicates. Figure 2 shows the illustration of the experimental design. The main plot had the plant species while intra row spacing treatments were in subplots at intra-row spacing of 30, 40, 50 and 60cm and constant inter-row spacing of 100cm (*D. erecta*, *H. patens*, *B. sempervirens, A. wilkiesiana and F. retusa*). Main plot size was plant species while sub plot size was the intra-row spacing at 2x4m per plot.

Transplanting and Management of the Established Greenery

Cuttings used for this study were raised through semi-hardwood stem cuttings of 10–15cm length rooted in polyethylene pots of size 19x12.5cm, filled with forest topsoil collected within the experimental site. All cuttings, with the same height and no branches, were transplanted at 11 weeks old. The plants were rainfed but supplementary watering was carried out equally on all plots if necessary. An insecticide, DD force (active ingredient: Dichlorvos 1000g LEC^{-1}, by Hubei Sanonda Co. Ltd, China) was applied at the recommended rate to prevent insect infestation. Weeding was done manually using a hoe as the need arose. A hedge shear (manual) was used for trimming of the shoots of the hedge plants at a height of 0.5m beginning from 22WAT and subsequently from 25-43WAT at 3week intervals.

Data Collection

Data were collected from randomly selected plants on the field (5 plants/plot or 5 plants/ treatment). Height was measured using a measuring tape from the plant base to the apex, the number of leaves per plant and number of branches were counted from 2WAT to 22WAT before the commencement of trimming. Canopy space per plant was estimated as the total foliage circumference. A measuring tape was used to take the radius of the canopy which was used to calculate the canopy space using the formula of circumference of a circle ($2\pi r$), where π=3.142 and r=radius (Owolabi et al 2019). First trimming was done when the plants for each species attained a height of 0.5m after transplanting, using a hedge shear and subsequently at 3 weeks interval to remove the top regrowth shoot, maintaining 0.5m height with the use of trimming shears. Trimmed biomass was determined by weighing trimmings after each cutting to know the amount of regrowth.

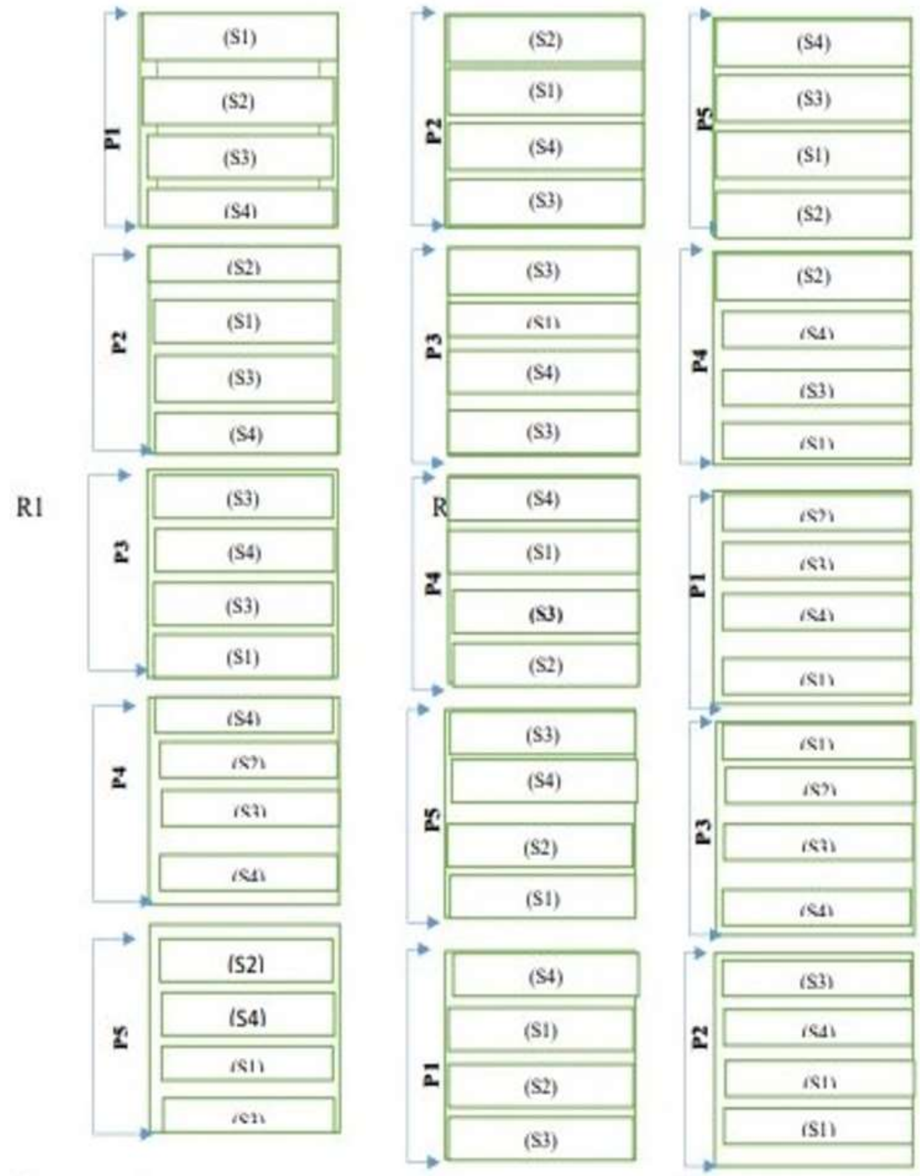

Figure 2. Illustration of the experimental design

Plant Species

Duranta repens (Yellow bush)-(P1), *Hamelia patens* (Fire bush)-(P2) *Ficus retusa* (Yellow ficus)-(P3), *Buxus sempervirens* (Boxwood/West indies)-(P4) *Acalypha wilkesiana* (Copper leaf)-(P5)

Intra Row Spacing

100x30cm-(S1), 100x40cm-(S2), 100x50cm-(S3), 100-60cm-(S4)

Growth characteristics and post trimming

Post-trimming shoot regrowth height was estimated by measuring the length of the new shoot regrowth, ten days after trimming and converted to mm per day, as shoot regrowth rate. Aesthetic appearance of each species was captured with a camera (Tecno W3 and 5Megapixels to produce image of 2582x1936) before and after each trimming. Aesthetic data for trimming were scored using a five point Lokert scale (1–No hedge formation, 2–Scanty hedge, 3–Semi-dense hedge, 4–Dense hedge and 5–Very dense hedge) to determine hedge density. The data were transformed using square root transformation method (Maidapwad and Sananse 2014). Flowering information was taken when it was observed that some of the plants were flowering. Data collected were analyzed using Gen Stat statistical software package edition 5 following analysis of variance procedures. Means were separated using Least Significant Difference (LSD) for main effects using line graph and Duncan's Multiple Range Test for Interactions, presented in tables below, at 5% probability level.

RESULT AND DISCUSSION

Growth Performance of Hedge Species

Growth characteristics among the hedge plant species significantly ($p \leq 0.05$) differed across all sampling periods. Height of plants was in the order of *H. patens* > *B. sempervirens* > *A. wilkesiana* > *F. retusa* > *D. erecta* from 4 to 22WAT. (Figure 3). *B. sempervirens produced* the most number of leaves per plant followed by *D. erecta*, *H. patens*, *A. wilkesiana and F. retusa* (Figure 4). The plant species were also significantly different ($p \leq 0.05$) with respect to the number of branches per plant. The number of branches produced per plant was in the order of *D. erecta* > *H. patens* > B. *sempervirens* > *F. retusa* > *A. wilkesiana* at 16WAT–22WAT (Figure 5).

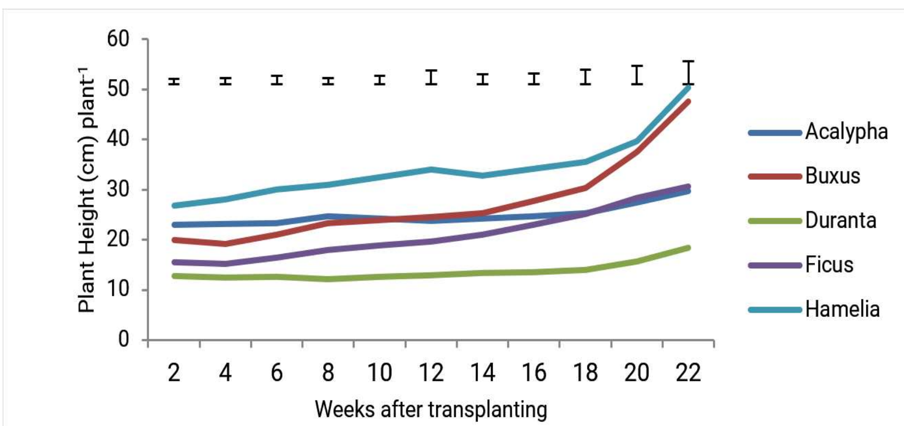

Figure 3. Plant height (cm) as influenced by plant species 2-22 weeks after transplanting

Differences in the canopy space among plant species were not significant ($p \leq 0.05$) except at the 3rd (31WAT) pruning time. However, *A. wilkesiana* had wider canopy space than the other hedge plants with the least being *F. retusa* (Table 2).

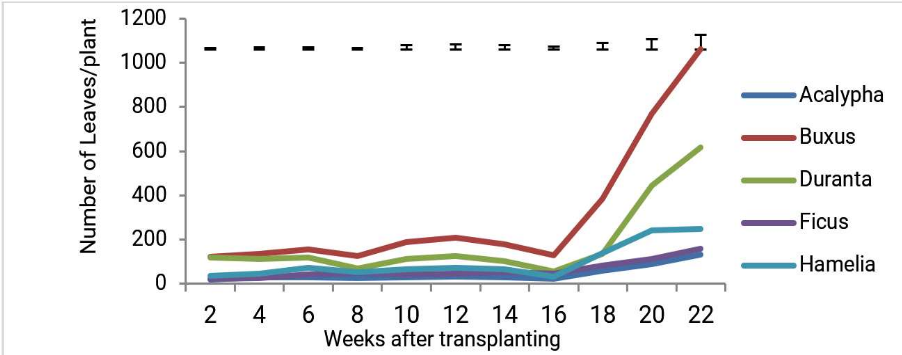

Figure 4. Number of Leaves as influenced by plant species, 2-22 weeks after transplanting

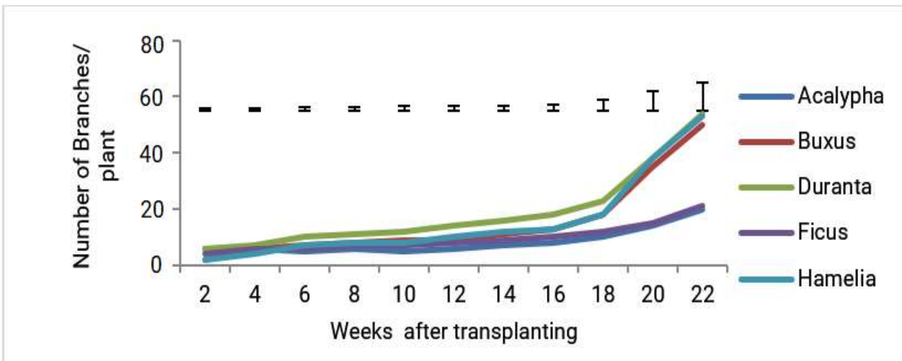

Figure 5. Number of branches as influenced by plant species, 2-22 weeks after transplanting

Table 2. Canopy space (cm) as influenced by plant species at 25-31WAT

Species	Trimming Time		
	1	2	3
A. wilkesiana	115.91	136.65	159.53
F. retusa	110.65	121.72	130.12
B. sempervirens	133.48	146.83	133.14
D. erecta	121.27	151.27	152.50
H. patens	115.65	130.72	138.12
LSD (0.05) ($p \leq 0.05$)	Ns	Ns	11.27

Note: Trimming commenced when the plant reached 0.5m after transplanting. Trimming was carried out at 3-week intervals.

Plant height, number of leaves and number of branches are the morphological growth characteristics used most in the selection of hedge plants for landscape use (Hitchmough 1994, Kendal et al 2008). These are the characteristics that affect the appearance of hedge plant formation in a landscape. This study showed that as the plants increased in height, the number of leaves and number of branches tended to increase which resulted in hedge formation. Plants with prolific branching and high number of leaves have the tendency to produce high shoot density when trimmed and this may have implications on the trimming frequency. This supports the observations of Kendal et al (2008) that the rapid increase in height affects both appearance of the hedge, and the maintenance inputs required to control the size of the hedge. The plant species (*H. patens*, *B. sempervirens, A. wilkesiana*, *D. erecta* and *F. retusa*) that were selected for this study increased steadily in height, number of leaves and number of branches across the weeks after transplanting at a significantly different growth rate. It was expected that there could be variation in their growth characteristics due to their genetic diversity. *H. patens*, *B. sempervirens, A. wilkesiana* were spreading in habit this provided chances of adequate branching and higher leaf density. This agrees with Hessayon (2008) that the significant differences in growth rate between species was a more important distinguishing characteristic for hedge plant selection. The plant species responded to trimming the same way at 1st and 2nd trimming. The significant difference at 3rd trimming may be attributed to an increase in branching and foliage density. This indicates that regular trimming of hedge plants can increase the plant canopy density.

Hedge Plants Growth Performance Under Plant Spacing

Responses of hedge plant species to spacing significantly ($p \leq 0.05$) varied. The tallest plants were observedat spacing of 100x40cm while shorter plants were recorded below 100x50cm spacing (Figure 6). Plants spaced at 100x60cm produced the highest number of leaves/plant, followed by 100x40cm, 100x30cm and 100x50cm (Figure 6). The effect of spacing on the proliferation of branches among all hedge plant species was not significant ($p \leq 0.05$) (Figure 7).

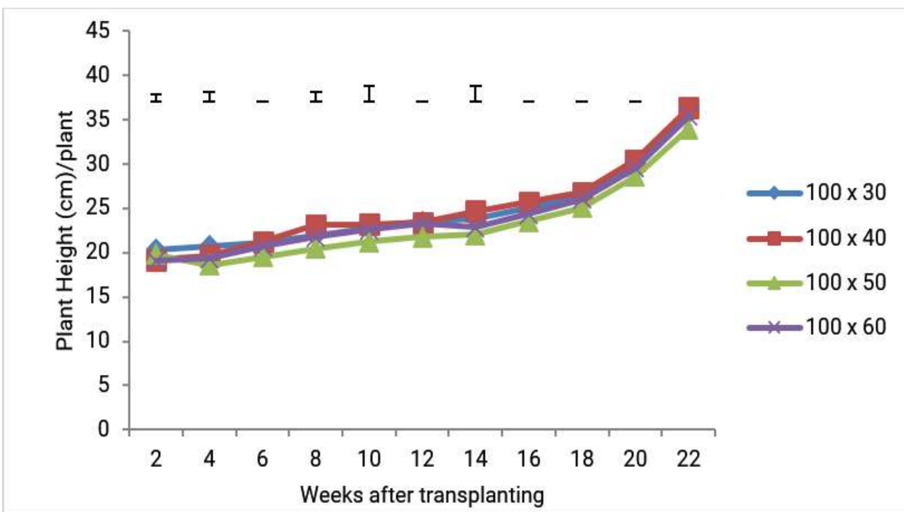

Figure 6. Plant height (cm) as influenced by spacing, 2-22 weeks after transplanting

Spacing had significant ($p \leq 0.05$) effect on the canopy space of hedge plants with those from 100x50cm and 100x30cm spacing having the widest and least canopy space per plant (Table 2). Plant Species that were transplanted at 100x30cm and 100x40cm spacing produced the tallest plants with high leaf density this supports the suggestion of Kozlowski and Pallardy (1997) that smaller spacing enhanced considerably the plant height to be used for their mass effect as hedges. This is what most users want – fast growing plants in terms of height, leaves and branching that will quickly result in the aesthetics that they desire for their landscape, with least plant pruning frequency. The effect of spacing was significantly highest at 100x40cm suggesting that it is more economical to plant at the wider spacing and wasteful to plant these hedges more densely. Intra-row spacing is a critical factor in hedge formation, because of the spacing affected response of the plant species to hedge formation. This study revealed that some plant species are more suitable for hedging if given the right spacing while some would be more suitable only as informal hedges.

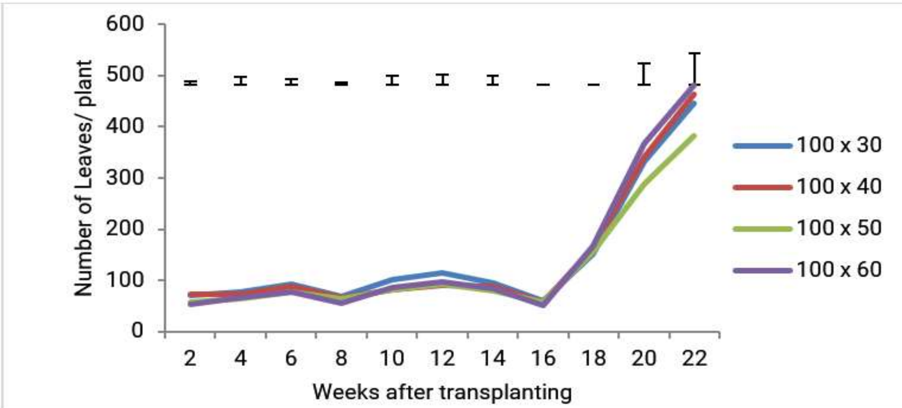

Figure 7. Number of leaves as influenced by spacing, 2-22 weeks after transplanting

The number of branches is one of the factors to consider when selecting hedge plants for early hedge formation. Spacing of 100x50cm and 100x60cm (Figure 8) produced more branches due to the spreading habit of all the species tested and the spacing provided room for spreading. Hessayon (2008) stated that rapid lateral growth of the hedge plant will be prevented where growing space is restricted. Spacing of 100x40cm had a restriction similar to this report by Hessayon (2008). This showed that plant species have the tendency to branch more when planted with a wider spacing as a single row of hedge species with adequate room for branching. However, wider spacing may be considered for some plant species based on their branching habit.

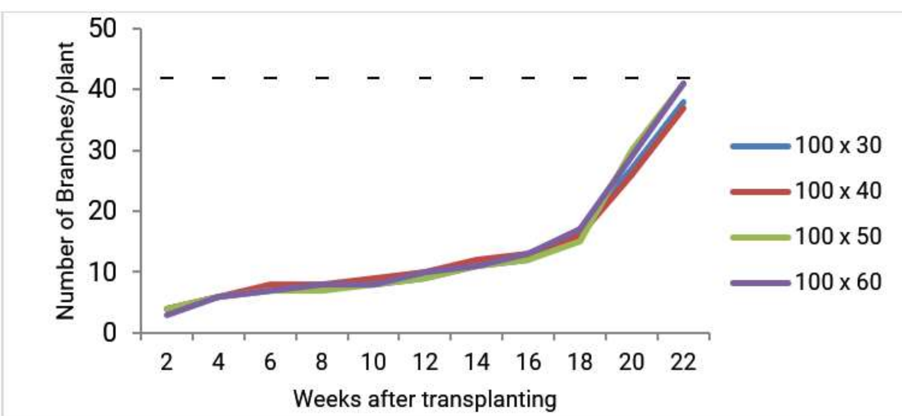

Figure 8. Number of branches as influenced by Spacing, 2-22 weeks after transplanting

Growth characteristics and post trimming

Spacing had significant ($p \leq 0.05$) effect on the canopy space of hedge plants with those from 100x50cm and 100x30cm spacing having the widest and least canopy room per plant (Table 3). Canopy space of all five species increased across trimming time due to the regular trimming at 3-week intervals. The significant differences that were observed on the canopy space among the plant species (*H. patens*, *B. sempervirens, A. wilkesiana*, *D. erecta* and *F. retusa*) was based on their physiological differences in terms of their different growth habits. *H. patens*, *B. sempervirens, A. wilkesiana* were spreading in nature while *D. erecta* and *F. retusa* were erect in nature. This actually affected their density with increases in the shoot regrowth after trimming. This supports the report by Hessayon (2008), that a wide range of species have the capacity to develop high shoot densities when regularly trimmed, which also increases the canopy density of the plant. The 100x50cm spacing gave the widest canopy while the 10x30cm spacing gave the least suggesting that very close spacing does not necessarily lead to quick formation of a dense hedge.

Table 3. Canopy circumference (cm) as influenced by intra-row spacing at 25-31WAT

Intra-row Spacing (cm)	Trimming Time		
	1	2	3
30	108.92	124.19	123.23
40	115.45	129.53	142.97
50	137.3	162.25	151.07
60	119.64	140.5	146.46
LSD (0.05) ($p \leq 0.05$)	Ns	27.286	10.08

Note: Trimming commenced when the plant reached 0.5m at 22weeks after transplanting. Trimming was carried out at 3-week intervals.

Effect of Interaction of Plant Species and Spacing on Growth Characteristics

Hedge species with spacing interaction significantly varies ($p \leq 0.05$) for the plant height, number of leaves and flowering nature of the hedge plants. Spacing *H. patens* at 100x30cm produced the tallest plants followed by *A. wilkesiana*, *Buxus sempervirens*, *F. retusa* and *D. erecta*. Spacing of 100x40cm, 100x50cm and 100x60cm for all five species showed no significant difference (Table 4). However, at 100x30cm, *H. patens* had the tallest plants, followed by *B. sempervirens* at 100x40cm > *Ficus retusa* at 100x30cm > *A. wilkesiana* at 10x40cm > *D. erecta* at 100x30cm (Table 4).

There was significant ($p \leq 0.05$) interaction of plant species and spacing on the number of leaves. At 100x30cm, *B. sempervirens* had the highest number of leaves followed by *D. erecta*, *H. patens* and *A. wilkesiana*. Significant ($p \leq 0.05$) interaction was observed at 100x40cm and 100x50cm. At 100x60cm *D. erecta* had the highest number of leaves, followed by *B. sempervirens*, *H. patens* and *A. wilkesiana* (Table 5). At 100x30cm *B. sempervirens* had the highest number of leaves, followed by *D. erecta*, *H. patens*, and *A. wilkesiana,* in that order. *A. wilkesiana* and *H. patens* had profuse flowering from 2 weeks after transplanting (WAT) throughout the period of the study. *Buxus* had sporadic flowering at 12WAT and profuse flowering at 22 WAT. No flowering was observed for *D. erecta* and *F. retusa.*

Table 4. Plant Height (cm) as influenced by interaction of shrub species and intra-row spacing at 4, 12 and 20 weeks after transplanting

Species	Intra-row Spacing(cm)	Weeks After Transplanting		
		4	12	20
A. wilkesiana	30	25.09cde	22.36e-m	25.27i-p
	40	20.79fgh	24.23e-h	28.49ij
	50	22.64c-g	23.88e-j	27.48i-m
	60	23.96c-g	24.75ef	28.23ij
B. sempervirens	30	19.77ghi	24.14e-i	36.43a-g
	40	19.28g-j	26.43e	39.82ab
	50	18.78g-l	23.27e-k	35.07b-h
	60	18.86g-k	24.6efg	38.78a-e
D. erecta	30	12.95nop	14.59pq	17.17q
	40	12.83nop	13.17pq	16.84q
	50	10.53p	11.17pq	14.51q
	60	13.25nop	12.86pq	14.34q
F. retusa	30	14.43mno	20.97f-m	30.21h
	40	15.92i-n	19.45hi-o	28.21i-l
	50	15.54i-n	17.33m-p	27.73i-m
	60	15.13k-o	20.74f-n	27.06i-o
H. patens	30	31.52a	35.55a	42.05a
	40	29.45b	33.63abc	38.99a-d
	50	25.43cd	33.22a-d	38.19a-f
	60	25.52bc	33.82ab	39.45abc

Note: Means followed by the same alphabet in the same column are not significantly different at 5% probability level of DMRT

Table 5. Number of Leaves (per plant) as influenced by interaction of Shrub Species and Intra-row Spacing at 4, 12 and 20 weeks after transplanting

Species	Intra-row Spacing (cm)	Weeks After Transplanting		
		4	12	20
A. wilkesiana	30	35i	26k	82j
	40	27i	38jk	102ij
	50	29i	32jk	82j
	60	33i	35jk	92j
B. sempervirens	30	169a	289a	710a-d
	40	156ab	180bcd	804ab
	50	124bcd	190b	719abc
	60	95c-g	182bc	850a
D. erecta	30	119cde	138c-f	512ef
	40	110c-f	140cde	514e
	50	90d-h	111e-h	273hi
	60	126bc	119efg	473efg
F. retusa	30	24i	44jk	121ij
	40	31i	38jk	100ij
	50	25i	48ijk	115ij
	60	27i	57ijk	115ij
H. patens	30	42i	71h-k	233hij
	40	39i	56ijk	184hij
	50	53i	77g-j	250hil
	60	46i	93e-i	303gh

Note: Means followed by the same alphabet in the same column are not significantly different at 5% probability level of DMRT

Post-trimming Shoot Regrowth Length as Influenced by Plant Species and Spacing

The plant species studied had significant differences in terms of post trimming shoot regrowth, in all the weeks from 25WAT to 43WAT. *D. erecta* had the highest regrowth shoot height following the 1st and 2nd trimming time, while *B. sempervirens, A. wilkesiana* had the least. The effect of spacing on shoot regrowth height was significant at the 3rd, 4th and 5th trimming times. The highest regrowth shoot length was observed at 100x40cm spacing followed by 100x30cm (Table 6). There were significant differences in the shoot regrowth of the plant species with *B. sempervirens* and *D. erecta* having higher shoot regrowth after trimming than *H. patens* and *B. sempervirence*. This supports the criteria for selection of hedge by Guevarra (1978) which states that a hedge should have the ability to regrow quickly after trimming. The inability of *H. patens* and *A. wilkesiana* to regrow as fast as the others maybe due to their constant flowering throughout the period of the study and this is in agreement with Guevarra (1978) who said the "sink" effects of flowers restricts carbohydrate accumulation in the roots and lower stems and would then depress the rate of regrowth and new tissue formation. Such plants are slower to recover after each cutting. The effect of spacing was significantly highest at 100x40cm suggesting that it is more economical to plant at the wider spacing and wasteful to plant these hedges at 100x30cm.

Table 6. Post-trimming shoot regrowth length (mm/day) as influenced by plant species and spacing

Species	Weeks After Transplanting						
	25	28	31	34	37	40	43
	Trimming Time						
	1	2	3	4	5	6	7
A wilkesiana	2.6	3.9	3.3	3.0	3.9	0.0	0.0
B. sempervirens	7.5	8.0	10.6	15.9	11.5	10.0	11.2
D. erecta	9.4	13.1	0.0	0.0	0.0	0.0	0.0
H. patens	7.5	7.8	8.4	12.1	9.4	7.2	8.2
LSD(0.05)	0.96	2.57	0.71	1.26	0.7	0.81	1
Intra-row Spacing (cm)							
30	5	5.7	3.9	5.4	4.5	3.3	3.6
40	5.2	7.6	5.1	7	5.6	3.5	3.6
50	5.6	6.2	4	5.5	4.5	3.4	4.2
60	5.8	6.7	4.9	6.9	5.3	3.7	4.2
LSD(0.05)	Ns	ns	0.64	1.13	0.62	ns	Ns

Trimming time (3 weeks interval)-showing 1st to 7th trimming times when each plant attains height of 0.5m ns-not significant

Post-trimming Fresh and Dry Biomass as Influenced by Plant Species and Spacing

A good hedge plant has been characterized as one with the ability to produce new regrowth shoots after trimming. The ease of regrowth is an index of ability to sustain a hedge shape. Hence, biomass quantity derived from trimmed regrowth shoots is considered as having a direct relationship with hedge formation and the sustenance of a designed hedge. It has been reported by Kozlowski and Pallardy (1997); Kendal et al (2008) that the process of regularly trimming hedge plant biomass result in an increase in canopy density as shoot density is increased by the removal of the terminal bud, which, in turn, releases dormant buds further down the stem. Plant species showed significant differences in post-trimming fresh biomass. *D. erecta* had the highest post-trimming biomass after the 1st trimming compared to the other plant species. There were significant differences in terms of the effect of spacing on fresh biomass except at 2nd, 4th and 5th trimming. The 100x30cm spacing and 100x40cm resulted in the highest fresh biomass at 1st trimming (Table 7). Plant species showed significant differences in post trimming dry biomass production except at the 7th trimming time. Highest dry biomass was recorded for *D. erecta* in the 1st trimming time and *Acalypha* at the 2nd–5th trimming times. The effect of spacing on dry biomass was significant at 1st, 3rd, 6th and 7th trimming times. Spacing of 100x30cm and 100x40cm had the highest yield in terms of post-trimming dry biomass production (Table 8).

Table 7. Post-trimming fresh biomass (g plot^{-1}) as influenced by plant species and spacing

Species	Weeks After Transplanting						
	25	28	31	34	37	40	43
	Trimming Time						
	1	2	3	4	5	6	7
A. wilkesiana	1380	1288	1416	787	878	0	0
B. sempervirens	927	257	566	886	975	694	409
D. erecta	1550	259	0	0	0	0	0
H. patens	345	224	247	440	484	315	376
LSD (0.05)	333.8	191.9	246.7	252.6	394.4	128	Ns
Intra-row Spacing (cm)							
30	1272	564	743	816	917	635	487
40	1262	503	825	701	811	526	364
50	983	583	854	728	818	467	381
60	686	378	551	572	570	390	338
LSD (0.05)	298.5	Ns	220.7	Ns	Ns	114.5	44.7

Trimming time (3 weeks interval)-showing 1st to 7th trimming times when each plant attains height of 0.5m. Ns-not significant

Table 8. Post-trimming dry biomass (g plot^{-1}) as influenced by plant species and intra-row spacing

Species	Weeks After Transplanting						
	25	28	31	34	37	40	43
	Trimming Time						
	1	2	3	4	5	6	7
A. wilkesiana	371	247.4	272.2	200.2	241	0	0
B. sempervirens	301	78	167.4	173.4	191	161.3	129.6
D. erecta	465	84.5	0	0	0	0	0
H. patens	110	51.5	70.2	71.2	88	78.9	109.2
LSD (0.05)	108	46.49	60.69	42	86.5	33.95	Ns
Intra-row Spacing (cm)							
30	398	132.8	170.8	146	191	148.7	151.4
40	368	105	175.8	162.6	182	120.5	104.8
50	283	137.3	205	156	185	114.8	121.4
60	199	85.9	128.1	128.4	135	96.4	100
LSD (0.05)	96.6	41.58	54.28	Ns	Ns	30.37	33.37

Trimming time (3 weeks interval)-showing 1st to 7th trimming times when each plant attains height of 0.5m. Ns-not significant

Growth characteristics and post trimming

Fresh and dry biomass after pruning were significantly different for the plant species with the highest being from *D. erecta*. However, the plant species had formed thick hedges by the end of the study supporting the report by Fordham (1967) that there is an increase in shoot density when species are trimmed. However, towards the end of this study, *H. patens* was noted to have great reduction in basal foliage which is most likely due to the frequent pruning that did not allow it to have adequate regrowth shoots for biomass. This suggests that *H. patens* is more suited for an informal hedge supporting the report that some shrubs are excellent when allowed to grow informally but lose their character when sheared (Hitchmough 1994). Spacing significantly affected fresh and dry biomass production. The 100x30cm and 100x40cm had the highest fresh and dry biomass. This is probably due to the larger number of plants species that the spacing accommodated.

Flowering

A. wilkesiana and H. patens had profuse flowering from 2 weeks after transplanting (WAT) throughout the period of the study. *B. sempervirens* experienced sporadic flowering at 12 WAT and profuse flowering at 22 WAT. However, flowering stopped at the onset of pruning. No flowering was observed for *D.erecta and F. retusa.* Flowering was consistent and showed throughout the study for *A. wilkesiana and H. patens*. Loss of basal foliage were observed in *H. patens* when trimmed. This loss of basal foliage is most likely due to the consistent flowering and also due to trimming as suggested by Hessayon (2008) that this species may be more suitable as an informal flowering hedge. *A. wilkesiana* flowered throughout the period of the study with non-showy flowers, this is probably the reason for the very slow regrowth rate of *A. wilkesiana* after pruning while B. *sempervirens* experienced sporadic flowering and profuse flowering from 22WAT most likely due to the onset of rain.

Aesthetic Impression of the Plant Species

Visual impression of species shown in Plates 2 shows no hedge formation prior to trimming at 22WAT. Plates below show progression in hedge formation of the species as trimming takes place. *B. sempervirens* forms a hedge early, followed by *H. patens*, *A. wilkesiana* and *D. erecta*.

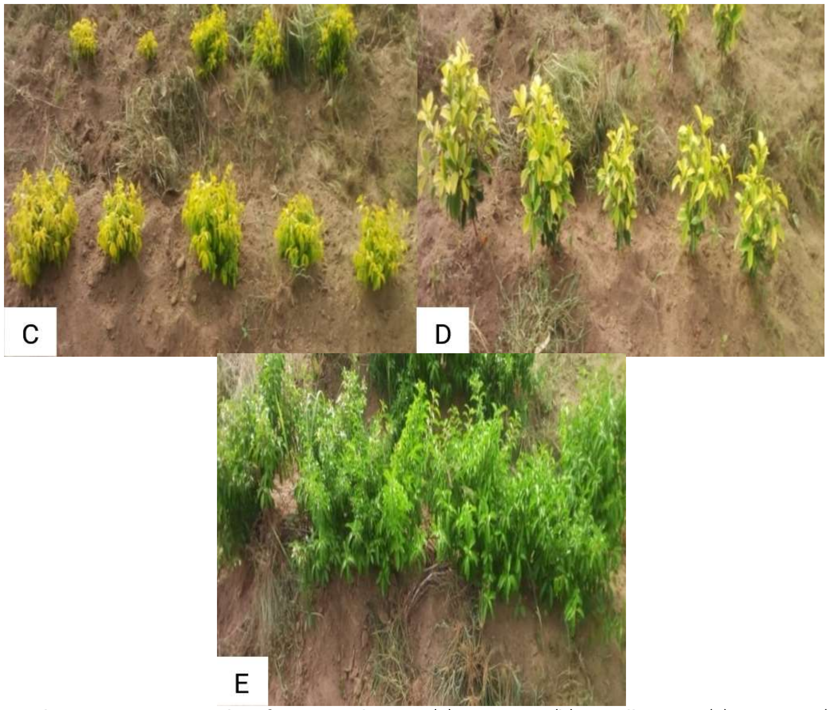

Plate 2. Plant Species 22 weeks after transplanting (a) *H. patens* (b) *A. wilkesiana* (c) *D. erecta* (d) *F. retusa* and (e) *B. sempervirens*

Aesthetic Impression and Hedge Formation as Influenced by Interaction of Plant Species and Intra-Row Spacing

B. sempervirens formed a dense hedge early after trimming, at 100x40cm in the 31[st] WAT, followed by *H. patens A. wilkesiana* and *D. erecta* in that order (Table 9). Plates 3 to 5 show the progression in hedge formation of species as trimming takes place. Therefore for hedge formation it is appropriate to plant the hedge plant species used in this work based on the spacing given in Table 10.

Table 9. Aesthetic impression and hedge formation as influenced by interaction of plant species and intra-row spacing at 25-43 weeks after transplanting

Species	Intra-row spacing (cm)	(Weeks after transplanting)						
		25	28	31	34	37	40	43
H. patens	30	1.0b	1.4b	1.7b	1.7b	2.0b	2.2a	2.2a
	40	1.0b	1.0c	1.4c	1.7b	1.7c	2.0b	2.0b
	50	1.0b	1.0c	1.0d	1.4c	1.4d	1.7c	2.0b
	60	1.0b	1.0c	1.4c	1.4c	2.0b	2.0b	2.2a
A. wilkesiana	30	0.0c	0.0d	1.4c	1.4c	1.7c	2.0b	2.0b
	40	0.0c	0.0d	1.4c	1.4c	1.7c	2.0b	2.0b
	50	0.0c	0.0d	1.0d	1.4c	1.7c	1.7c	2.0b
	60	0.0c	0.0d	1.0d	1.0d	1.0e	1.4d	1.4d

Table 9. continued

Species	Intra-row spacing (cm)	(Weeks after transplanting)						
		25	28	31	34	37	40	43
D. erecta	30	0.0c	0.0d	0.0e	0.0e	0.0f	1.7c	2.0b
	40	0.0c	0.0d	0.0e	0.0e	0.0f	2.0b	2.2a
	50	0.0c	0.0d	0.0e	0.0e	0.0f	1.4d	1.7c
	60	0.0c	0.0d	0.0e	0.0e	0.0f	1.0e	1.4d
B. sempervirens	30	1.4a	1.4b	1.7b	2.0a	2.2a	2.2a	2.2a
	40	1.4a	1.7a	2.0a	2.0a	2.2a	2.2a	2.2a
	50	1.0b	1.0c	1.4c	2.0a	2.2a	2.2a	2.2a
	60	1.0b	1.4b	1.7b	2.0a	2.2a	2.2a	2.2a

Note: Means followed by the same alphabet in the same column are not significantly different at 5% probability level of DMRT

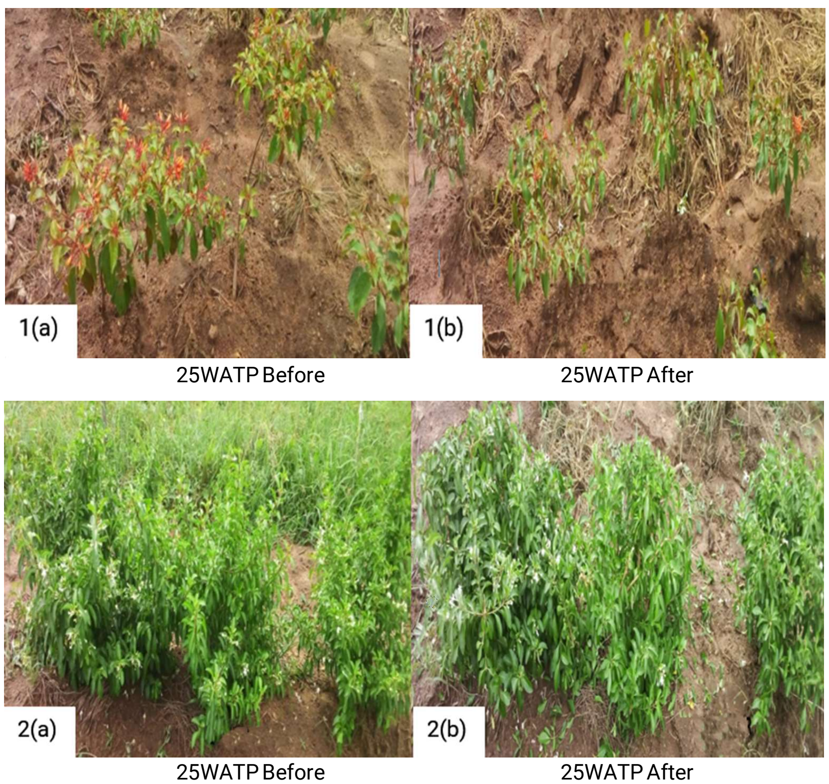

Plate 3. Plant Species (a) before and (b) after 1st pruning, 25 weeks after transplanting, 1(a & b) *H. patens* and 2(a & b) *B. sempervirens*

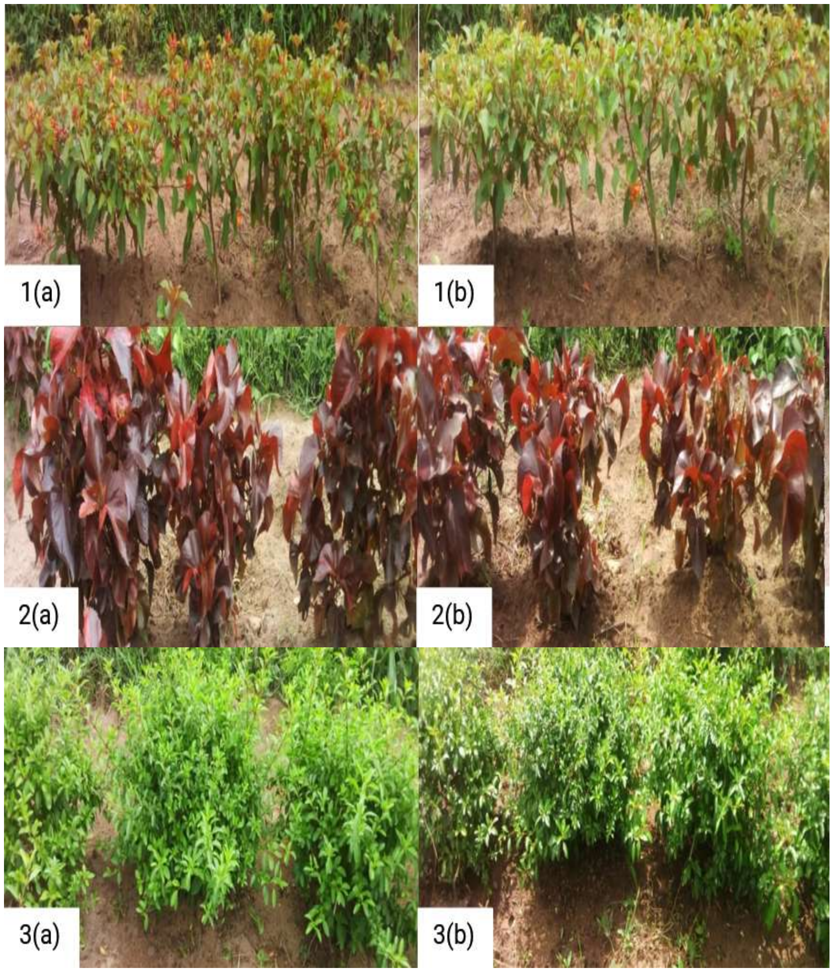

Plate 4. Plant Species (a) before and (b) after 3rd trimming, 31 weeks after transplanting, 1(a & b) *H. patens*, 2(a & b) *A. wilkesiana* and 3(a & b) *B. sempervirens*

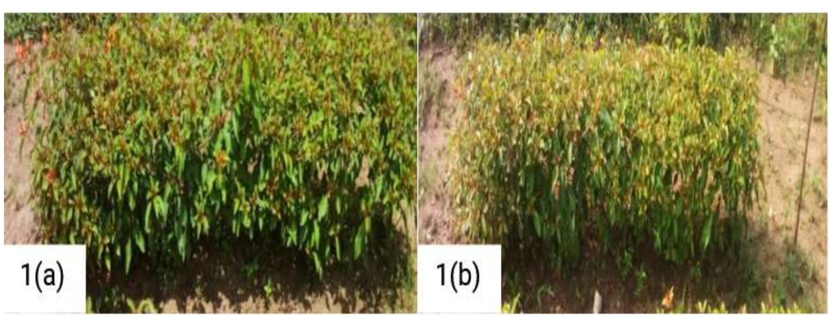

Plate 5. Plant Species (a) before and after 7th pruning, 43 weeks after transplanting, 1(a & b) *H. patens*, 2(a & b) *A. wilkesiana*, 3(a & b) *D. erecta* and 4(a & b) *B. sempervirens*

Plate 5. continued

Table 10. Summary of the species and respective spacing suitable for hedge formation

S/n	Species	Spacing (cm)
1	*B. sempervirens*	40
2	*H. patens*	30
3	*D. erecta*	40
4	*A. wilkesiana*	40

CONCLUSION

This study shows that intra-row spacing is a critical factor in the use of plant species as a hedge in landscaping. It also shows that among the plant species used, suitability for hedging is in the order of *B. sempervirens*> *H. patens*> A. *wilkesiana* > *D. erecta* at a specific spacing. Spacing of 100x40cm is considered suitable for hedge formation in a landscape. *Ficus retusa* species, which did not attain the 0.5m for trimming, was considered not suitable for use as a hedge plant.

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