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Foliar traits of jasmine plants intercropped in coconut

V. Arunachalam · D. V. S. Reddy

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Abstract Shade is one of the important limiting factors in intercropped agro-ecosystems. Objective of this work is to analyze the role of eight foliar traits of juvenile plants of five different species of *Jasminum* grown under coconut shade. The results reveal the shade tolerant *J. pubescence* to produce more number of nodes and longer shoots in all the three seasons studied. *J. grandiflorum* produced longer leaves and internodal distance than other species tested. Winter season shoots were longer with more number of nodes and longer internodal distances than rainy season. Results are discussed in relation to the adaptive behavior of plants to shade.

Keywords Adaptation · *Cocos nucifera* · *Jasminum pubescence* · Ornamentals · Shade

Introduction

Intercropping in coconut plantations is an important subject of many investigations (Mapa 1995; Braconnier et al. 1998; Reddy and Biddappa 2000). But there are few reports on ornamental plants as intercrops in coconut plantations (Sudha and Subramaniyam 1992). Ornamental plants possess some important morpho-physiological parameters, which play a major role in adaptation to shade. They are thin leaves, higher chlorophyll content, presence of lens shaped epidermal and decrease in size and color of flowers/fruits (Middleton 2001).

Jasmine is an important flower crop belonging to the genus *Jasminum* and botanical family Oleaceae. Of the more than 200 species in this genus only few are cultivated or used in gardening. The crop is used in tropical countries in making garlands, hair decoration and in the perfume industry. Species level differences in plastic morphological response to light have been mainly in terms of leaf traits (Ninements et al. 2003). This work was taken up with an objective of understanding the response of juvenile plants of different species of Jasmine with varying photosensitivity responses when intercropped in coconut shade. Variation in response was analyzed through eight chosen foliar traits.

Material and methods

This experiment was laid out with the five species of *Jasminum* with four replications in a Randomized Block Design in the interspaces of 35 years old coconut palms in sandy loam soil located in "A" block of experimental fields of Central Plantation Crops Research Institute, Kasaragod, Kerala, India. Kasaragod is located in coastal humid tropics (17°48′ N 74°58′ E 3′ above mean sea level) and

V. Arunachalam (✉) · D. V. S. Reddy
Crop Improvement, CPCRI, Kudlu, Kasaragod, Kerala 671124, India
e-mail: vadivelarunachalam@yahoo.com

receives 3,000 mm annual rainfall in months of June to September. Minimum and maximum temperature at this location varies from 17°C in winter months to 38°C in summer months respectively. A plot size of alley space between four palms was used. All the *Jasminum* species were planted at 40 plants/plot except *J. grandiflorum*, where 24 plants/plot were planted. Coconut palms are spaced at 7.5 m × 7.5 m. Intercrops are planted leaving a empty space of 1.5 m from the coconut stem. Rooted cuttings of jasmines are planted on four raised beds made in each plot. Observations were recorded on eight plants in each plot. Two randomly chosen plants in each bed are used to represent the variation within plot.

Rooted cuttings of *J. grandiflorum*, *J. sambac and J. auriculatum* were obtained from Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. *J. pubescence (*Syn. *J. multiflorum)* was multiplied from existing plants at Kasaragod. *J. sambac* (ksd) was obtained from a farmers' plot at Kasaragod. Planting of jasmine plants occurred during Oct. 2001. Regular irrigation was provided to all the plants with sprinklers during summer months. Manuring and fertilizers applications were carried out with 2 kg of vermicompost and 100:150:100 gm/plant of N, P_2O_5, and K_2O, respectively. Other intercultural operations like hand weeding and pruning were given as per requirement. Observations are recorded on number of leafy nodes on the shoot, length of shoot, length of leaf, and width of leaf in each plant in one randomly chosen shoot. Internodal distance, leaf shape (width/length ratio), leaf area (length * width) and IL/LL (inter nodal length/leaf length ratio) have been estimated from these values. Data was recorded at three different seasons i.e., January 2002, August 2002 and January 2003.

Statistical analysis of data was carried out using factorial randomized block design model with five species as main effects and three seasons of measurement as sub effects. Standard statistical procedure (Fisher 1925) of F statistic involving null hypothesis testing was conducted by working out the variance ratio of between treatments and within treatments. The calculated variance ratio was compared with Fisher's table values at significance levels of 5% and 1% probability. Based on the difference between the calculated variance ratio to table values, the null hypothesis was accepted or rejected and degree of significant differences among the treatments was rated at probability level of 5% or 1% ($P < 0.05$) and ($P < 0.01$), respectively. SEM (standard error of mean) value was also worked out from the above procedure. This value is multiplied by appropriate t value at error degree of freedom to get critical difference. This critical difference was used to compare the treatment means. Based on the comparison, treatment means that are statistically at par are assigned with same alphabet and listed in Tables 1 and 2.

Principal component analysis of the data was worked out using standard procedures to reduce the set of variables to few important variables. A matrix of correlation coefficients between eight chosen foliar traits was first generated. Using these values of correlation coefficients the variation in the eight traits was partitioned into few main components known as PC axes. First axis PC 1 extracts maximum possible variation and PC 2 extracts further possible variation and so on. Non-hierarchical Euclidean cluster analysis method was used in the study. The PC scores obtained during the process for each trait in each of the PC axes was recorded. Algorithm developed by Spark (1973) implemented in the software SPAR 1.0 (Statistical Package for Agricultural Research) was used for this purpose.

Results

Five species of *Jasminum* during three seasons differed significantly for most of the characters studied (Tables 1 and 2). When the mean values of five species of jasmine plants are compared, *J. pubescence* had significantly large number (19.9) of leafy nodes. *J. grandiflorum* produced long shoots and large leaves. It showed the highest mean values for shoot length (94.2 cm), internodal distance (8.3 cm) leaf length (8.58 cm) and leaf width (3.88 cm). These values are statistically significant than other species. *J. auriculatum* had smallest leaves (4.92 cm) and also showed very slow growth during the experiment (Table 2).

Out of two winters and one rainy season studied, jasmine plants are slow in growth during rainy season with fewer nodes (7.2) and short shoots (38.4 cm). Number of nodes (>10) and length of shoot (>50 cm) remain high (Table 2) during winter seasons.

Table 1 Vegetative characters in 5 species of jasmine plants under coconut shade during three seasons

Season	Species	No. of nodes	Shoot length (cm)	Leaf length (cm)	Leaf width (cm)	Internodal distance (cm)	Leaf shape	Leaf area (cm^2)	IL/LL ratio
Jan-2003	*J. grandiflorum*	10.22 a	77.25 b	6.87 c	2.98	7.49 c	0.45	20.08	1.09
	J. sambac	8.13 a	37.22 a	4.64 a	3.33	4.66 b	0.74	15.29	1.00
	J. auriculatum	7.38 a	34.69 a	4.49 a	3.05	4.84 b	0.70	13.98	1.08
	J. pubescence	21.19 b	66.77 b	5.89 b	3.30	3.37 a	0.56	19.46	0.57
	J. sambac (Ksd)	6.49 a	36.34 a	5.21 ab	3.53	5.58 b	0.68	18.42	1.07
SEM		2.96	8.04	0.45	NS	0.64	NS	NS	NS
P>		0.01	0.01	0.01		0.01			
Aug-2002	*J. grandiflorum*	13.72 c	130.51 b	10.21 d	4.86 c	9.50 d	0.48	49.62 d	0.93 c
	J. sambac	9.40 a	46.06 a	6.62 bc	3.23 b	4.93 b	0.49	21.31 bc	0.75 a
	J. auriculatum	13.19 bc	55.80 a	5.86 a	3.15 b	4.23 a	0.54	18.51 ab	0.72 a
	J. pubescence	29.36 d	136.15 b	6.97 c	3.34 b	4.64 ab	0.48	23.31 c	0.67 a
	J. sambac (Ksd)	8.97 a	47.61 a	6.31 ab	2.87 a	5.36 c	0.46	17.98 a	0.85 b
SEM		2.04	11.20	0.28	0.25	0.39	NS	2.12	0.06
Sig *P*		0.01	0.01	0.01	0.01	0.01		0.01	
Jan-2002	*J. grandiflorum*	9.45 c	74.94 c	8.68 c	3.81 b	7.91 c	0.44 a	33.06 c	0.91
	J. sambac	4.83 a	17.71 a	6.21 b	3.75 b	3.68 a	0.61 b	23.42 b	0.59
	J. auriculatum	6.58 b	25.74 a	4.40 a	3.06 a	3.92 a	0.70 b	13.70 a	0.89
	J. pubescence	9.02 c	48.71 b	5.03 a	2.98 a	5.34 b	0.60 b	14.95 a	1.06
	J. sambac (Ksd)	6.12 ab	24.95 a	6.15 b	3.80 b	4.07 a	0.62 b	23.40 b	0.66
SEM		0.85	7.80	0.38	0.29	0.78	5.82	2.22	NS
P>		0.01	0.01	0.01	0.05	0.01	0.01	0.01	

Values followed by same alphabet are statistically at par

Seasonal differences were not significant for leaf width and IL/LL ratio. Leaf area of jasmine plants was found to increase from 17.45 cm^2 during Jan 2002 to 21.76 cm^2 during Jan 2003, as the plants grew older.

The species × season interaction was significant at $P < 0.01$ only for two traits internodal distance and leaf area. *J. grandiflorum* had longest internodes (9.5 cm) and recorded largest leaf area (49.62 cm^2) during Aug 2002 (Table. 1) *J. pubescence* had shortest internodal distance (3.37 cm) during January 2003. Leaf area of *J. auriculatum was lowest (13 cm^2)* during both winters studied.

Shoot length of the species was especially high during initial stage but during later growth stages *J.* pubescence was able to produce similar long shots (Table. 1). Of the different jasmine genotypes tested under coconut shade, only *J. pubescence* was successful with good growth, and early and profuse flowering. *J. auriculatum* was found to be very slow in growth and did not perform well in coconut shade. *J. grandiflorum* initially performed well but declined. Other three species showed intermediate reactions.

Shade sensitive *J. auriculatum* had smallest leaf area among the species studied. *J. grandiflorum* had the longest and widest leaves due to peculiar arrangement of thin leaflets than the other species studied.

Principal component analysis (PCA) of the eight traits shows the importance of few vegetative traits in contributing to divergence between the five jasmine species (Table 3). PCA is a multivariate technique to analyze many variables and to reduce to few important variables. It extracts structure from correlation matrix and factor scores show the relative importance of the variable. High factor loading of value above 0.5 shows significance of the variable. Three of the PC axes (PC 1, PC 2 and PC 3) together able to govern 99.73% of variation.

PC 1 contributed 56% of variation, which was mainly controlled by internodal distance. In this axis, internodal distance recorded a high factor loading of

Table 2 Mean values of foliar traits in five species jasmine plants and three seasons under coconut shade

Species	No. of nodes	Shoot length (cm)	Leaf length (cm)	Leaf width (cm)	Internodal distance (cm)	Leaf shape	Leaf area (cm^2)	IL/LL ratio
J. grandiflorum	11.13 b	94.23 c	8.58 c	3.88 b	8.30 c	0.45 a	34.25 c	0.97
J. sambac	7.45 a	33.66 a	5.82 b	3.43 a	4.43 a	0.61 bc	20.01 b	0.76
J. auriculatum	9.05 ab	38.74 a	4.92 a	3.09 a	4.33 a	0.64 c	15.39 a	0.88
J. pubescence	19.85 c	83.88 b	5.96 b	3.21 a	4.45 a	0.55 b	19.24 b	0.75
J. sambac (Ksd)	7.19 a	36.30 a	5.89 b	3.40 a	5.00 b	0.58 b	19.93 b	0.85
SEM	1.23	5.28	0.22	0.23	0.36	0.04	1.70	0.97
P>	0.01	0.01	0.01	0.05	0.01	0.01	0.01	NS
Seasons								
Jan-2003	10.68 b	50.45 b	5.42	3.24	5.19	0.63	17.45 a	0.96
Aug-2002	7.20 a	38.41 a	6.09	3.48	4.98	0.59	21.71 b	0.82
Jan-2002	10.93 b	57.36 b	6.23	3.40	5.30	0.57	21.76 b	0.85
SEM	1.23	5.28	0.22	0.23	0.36	0.04	1.70	0.97
P>	0.01	0.01	0.01	NS	0.05	0.01	0.01	NS
Species × *P* > season interaction	NS	NS	NS	NS	0.01	NS	0.01	NS

Values followed by same alphabet are statistically at par

−0.623 (Table. 3). IL/LL ratio scored lowest in this axis. PC 2 covered further 32% of variation in the eight traits. Here leaf width recorded a high factor loading of 0.626. PC 3 covered remaining 12% variation. Leaf shape with a factor loading of 0.799 governed this axis. Thus PCA highlights the importance of internodal distance followed by lead width and leaf shape. These three traits are major determinants of variation in the present study of jasmine plants grown in coconut shade.

Table 3 Latent vectors and roots in vegetative characters of jasmines

Trait	PC1	PC2	PC3
Number of nodes	0.303	0.465	0.456
Shoot length	−0.456	0.029	0.132
Leaf length	−0.250	−0.128	0.148
Leaf width	−0.133	0.626	0.122
Internodal distance	−0.623	0.111	−0.312
Leaf shape	−0.262	−0.331	0.799
Leaf area	0.366	−0.401	−0.041
IL/LL ratio	0.173	0.304	0.031
Eigen root	4.498	2.542	0.937
% Contribution to variation	56.23	31.78	11.72
% Contribution to cumulative variation	56.23	88.01	99.73

Discussion and conclusions

Phenotypic variation in stem and leaf traits in response to shade varies from species to species. In general, leaf angle, supporting branches, specific leaf area and internodal length together modify the foliage display architecture so as to enhance light harvesting efficiency (Valladares et al. 2002). Of the species tested, *J. grandiflorum* had longest shoots (94.23 cm) with medium number of leafy nodes (11.13) per shoot. But *J. pubescence* had medium long shoots but with maximum leafy nodes (19.85). Low light intensity enhances long shoots and long leaves in shade loving plants such as Sweet pepper (Rylski and Spigelman 1986) and *Lolim pernne* (Mika et al. 1998). But light loving plants tend to suffer by reduction in number of leaves, such as in shaded grapes (McArtney and Ferree 1999) and in carrots grown along with beans (Taungakava and Tofinga 2000). During low light stress, plants produce long shoots in search of light. Such long shoots supported by sufficient leafy nodes aid in enhancing the photosynthetic efficiency thus adapting to shaded environment.

Internodal distance was influenced by genetic (species) and environmental (seasonal) factors in our study. It was also found to be an important trait based on PCA with a high factor loading of −0.623 in PC1 (Table. 3). *J. grandiflorum* had longest internodes (9.5 cm) during Aug 2002 whereas it was short during both winter seasons studied. *J. pubescence* had shortest internodal distance (3.37 cm) during Jan 2003 (Table. 1). Longer internodes aid the plant to reach high in order to get light and also to grow vigorously and yield well. Timing of pruning affects internodal length and yield of *J. sambac* (Siddagangaiah and Rai 1988). They found long internodal length in *Jasminum sambac* plants pruned in May and shorter length in those pruned in June. Shade loving plants like Patchouli (Reglos and Guzman 1991) and forage plants (Lin et al. 2001) have the tendency to produce long internodes.

Seasonal differences were noticed for the vegetative characters in jasmines grown under coconut. Number of nodes, internodal distance and shoot length were higher in winter than in rainy season (Table 1). Winter flowering species *J. pubescence* performed best in subtropics (More 1980). As the experimental location receives high rainfall during months of June to September, due to clouds and rains the light availability as such is low during these months. This gives additional evidence to the importance of inernodal distance and number of nodes in shade adaptation.

Jasminum species differ in their morphological, physiological and biochemical traits. Their reaction to shade also varies. In our study, *J. auriculatm* has shown very low adaptation to coconut shade. Present study highlights the importance of internodal length, shoot length, and number of leafy nodes in adaptation of *Jasminum* to perform in canopy shade of coconut. The study also suggests the use of *Jasminum pubescence* as suitable intercrop in coconut gardens than other species of *Jasminum.*

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