

Variation in canopy characteristics of mango (*Mangifera indica* L.) cultivars from diverse eco-geographical regions

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Abstract

A study was conducted on 26 important Indian mango cultivars to examine their foliage density and canopy diffuse non-interceptance. Indirect measurement of Leaf area index (LAI) and diffuse non-interceptance (DNI) made using output of concentric silicon detectors, placed at five zenith angles on sensing head of LAI-2000 recorded significant variability in foliage density (LAI=1.18-4.48). Diffuse non-interceptance values also exhibited large variation and ranged from 0.02 to 0.36. UPGMA cluster analysis of the data revealed that Bangalora, Fazri, Neelum, Vanraj, Dashehari, Alphonso, Lucknow Safeda and Banganapalli had similarity in tree leaf component. Nisar Pasand, Kishan Bhog and Bombay Green had compact and dense canopy with more foliage component. Papatio and Fernandin exhibited comparatively less foliage under Lucknow conditions. Prabhashankar and Chausa showed similarity and were closer to compact canopy group. In general, east and north Indian cultivars recorded more foliage component, whereas Fernandin and Papatio canopies exhibited high DNI values. The cultivars recording more DNI produced fruits with better colour.

Key words: Mango, *Mangifera indica* L., foliage density, leaf area index, canopy, Indian cultivars

Introduction

Light interception is directly related with total dry matter production in several crops (Duncan *et al.*, 1973 and Monteith, 1977) and also holds good for fruit trees (Jackson and Palmer, 1977), however, the partitioning of dry matter is dependent on within canopy light distribution also. Optimised light distribution within canopy and its interaction with different parts is important for maximizing photosynthesis, flower bud formation, fruit growth and colour development (Rajan and Lal, 1999). Better understanding of canopy micro-climate particularly with regards to light distribution is associated with cultivars, cultural practices and climatic conditions. In tropics, several subtropically adapted mango genotypes like Langra and Dashehari develop huge and dense canopy with high leaf component indirectly causing poor light penetration, flowering and fruit quality (Yadav and Rajan, 1993).

Direct measurement of LAI in large heterogeneous tree canopies is difficult (Martens *et al.*, 1991). For replacing destructive leaf harvest method, which is usually undesirable and impractical for tree crops, researches have led to the development of methods based on allometry (Whittaker and Woodwell, 1968; Marshall and Waring, 1986). Refinements in allometric methods are responsible for improvement in indirect methods (Grier and Waring, 1974; Whitehead *et al.*, 1984), which still require much laborious fieldwork before its application in the orchard. Gap fraction analysis is one of the indirect method of estimating LAI (Campbell and Norman, 1989; Norman and Campbell, 1989). It has been successfully applied to the small plants and also to forest tree canopies. Recently, advances in instrumentation for measuring gap fraction in plant canopies and the development of gap fraction inversion models, from which canopy characteristics such as LAI and mean leaf inclination angle can be inferred, have increased the attractiveness of this method (Campbell, 1986).

Not much information is available on the variation in foliage density in mango varieties. Therefore, the present study considers the differences in canopy characteristics of important Indian mango cultivars under subtropical conditions studied by indirect method *i.e.*, gap fraction inversion model.

Methods and materials

The study was conducted on 26 Indian mango cultivars at Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow. Twenty years old trees, planted at the distance of 10 x 10m, were selected for the study. Radiation measurements, above and below canopy were taken on cloudy day with the help of five concentric silicon ring detectors on the sensing head of LAI-2000 (LI-Cor, Inc. Lincoln, NE). The data generated by concentric detectors, placed at five zenith angles was used for calculating gap fraction. Readings of above and below-canopy light conditions were used for the calculation of LAI and DNI. Below-canopy data were taken at four compass directions. Above-canopy data were taken by walking to an adjacent open space, immediately after recording each below-canopy reading. The LAI was calculated from the field measurements by using the software support for the plant canopy analyzer C-2000-90 Version 2.14 (LI-COR, 1992). Cultivars were grouped by subjecting the data to UPGMA (unweighted pair-group method using arithmetic averages) cluster analysis.

Results and discussion

Mango cultivars exhibited significant differences for their canopy characteristics (Fig. 1a,b). The cultivars had mean LAI value 2.94 with a range of 1.18-4.48 whereas, mean diffuse non-interceptance (fraction of the sky which can be seen from the

canopy) was 0.11 and it ranged from 0.02 to 0.36. The pattern of frequency distribution of LAI and DNI in cultivars was different (Fig. 2a,b) indicating curvilinear relationship between these two parameters. Most of the cultivars had LAI between 2-4. Whereas, more number of cultivars (88.4%) recorded DNI < 0.2. In general, east and north Indian cultivars like Bombay Green, Chausa, Nisar Pasand, Himsagar and Prabhaskanker recorded more foliage component (LAI>4). Fernandin, Papatio and Rataul canopies exhibited high diffuse non- interceptance values (DNI > 0.3). Most of the genotypes showing less diffuse non- interceptance like Bombay Green, Nisar Pasand and Prabhaskanker produced fruits with dark green colour at harvest. Since mango genotypes show eco-geographical dependence with regard to adaption, growth and productivity, foliage distribution within canopy is significantly affected by genotype x environment interaction.

The results indicated that the genetical divergence in the canopy characteristics like foliage density and diffuse non-interceptance exist in mango. These parameters were used for grouping of cultivars based on similarity percentage. Clustering pattern indicated that cultivars, Bangalora, Fazari, Neelum, Vanraj,

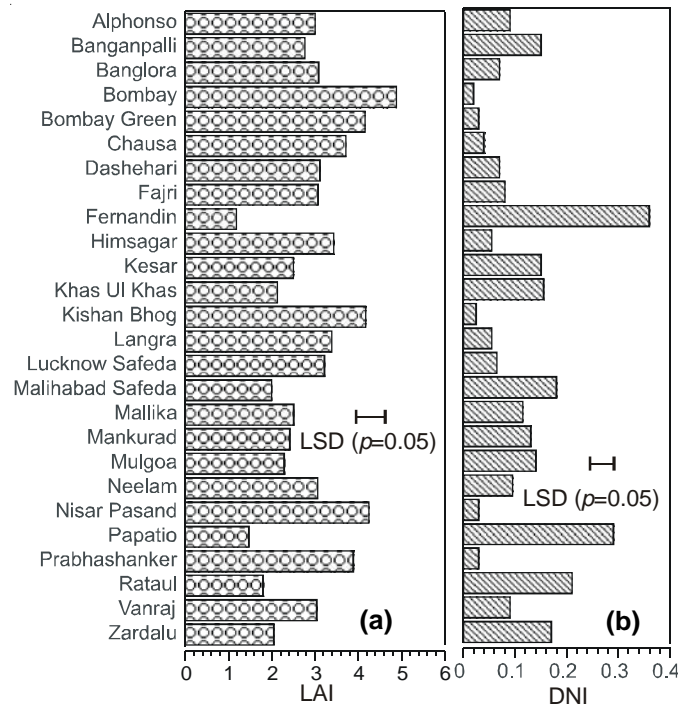


Fig. 1. Variation in LAI (a) and diffuse non interceptance (b) in different cultivars of mango studied under subtropical conditions.

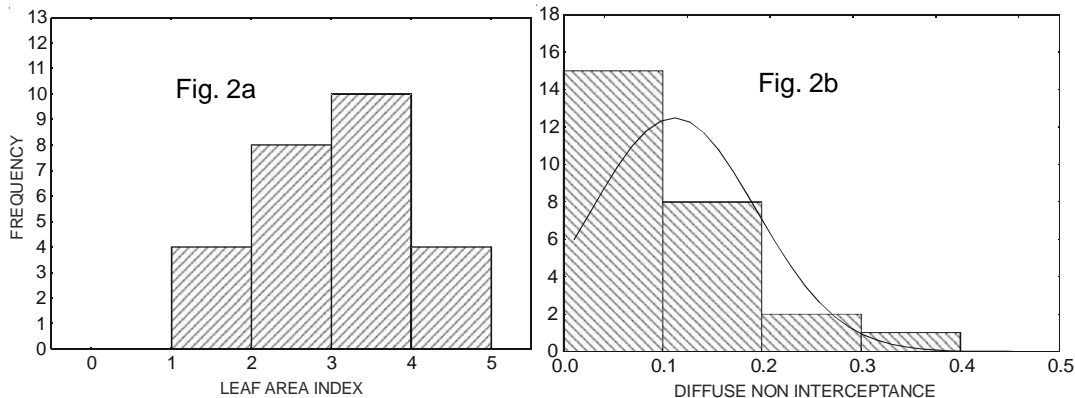


Fig. 2a. Frequency distribution of leaf area index and Fig. 2b. Frequency distribution of diffuse non-interceptance in 26 important mango cultivars.

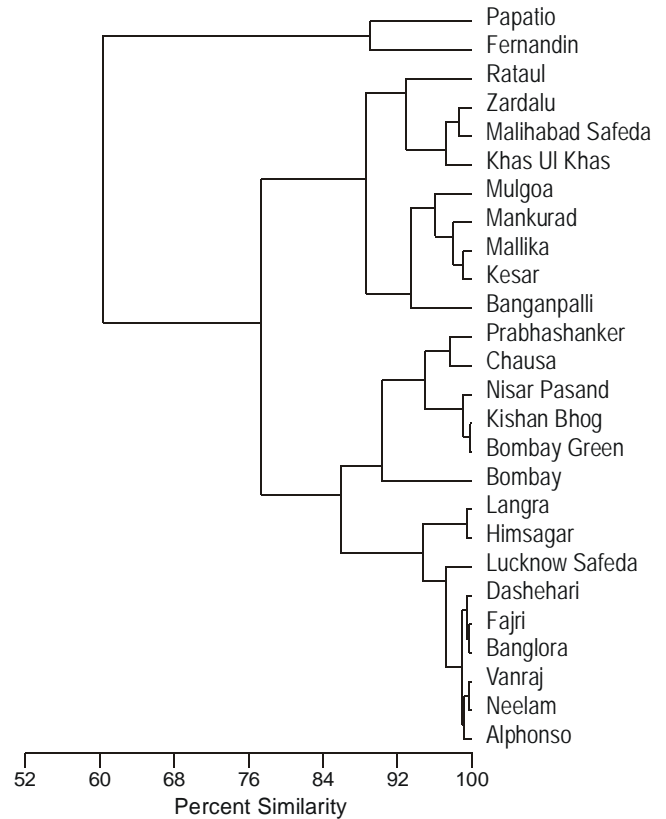


Fig. 3. UPGMA clustering of genotypes based on LAI and DNI values

Dashehari, Alphonso and Lucknow Safeda have similarity in canopy leaf component. Kesar, Mallika, Mankurad and Mulgoa were grouped in one cluster having semi compact canopy. Nisar Pasand, Kishan Bhog and Bombay Green had dense canopy with more foliage component. Papatio and Fernandin exhibited comparatively less foliage under Lucknow conditions. Prabhaskanker and Chausa showed similarity with each other and were closer to compact canopy group of Nisar Pasand, Kishan Bhog, Bombay Green. Himsagar and Langra showed similarity in canopy development behaviour (Fig. 3).

Variation in foliage density and DNI also indicates that there is significant difference in canopy structure of different cultivars and suggests that other than genotypic influence, this may occur under the influence of factors *i.e.*, vegetative growth, regularity of cropping and growth cycles in a year. Cultivars differ significantly in canopy architecture, thus exhibiting variation in DNI. Difference in foliage component of scion has been recorded with differential vigour of the scion imparted by rootstocks (Verheij and Verwer, 1973).

Foliage distribution in several mango cultivars is not uniform specially under North Indian conditions. Cultivars from south and west India show low foliage component as compared to north and east Indian cultivars. Some cultivars may also exhibit different growth habit under north and south Indian conditions due to ceasing growth under extreme temperatures in subtropics. In the present investigation, Fernandin and Papatio performed entirely different than the other cultivar (Fig. 3). The similarity between the cultivars from different ecological regions was also observed which indicates that differential canopy development is not solely dependant on the adaption rather variability in canopy characters exists in cultivars of the same eco-geographical region.

The relationship between yield and light interception by the canopy, which is dependant on the size and foliage density of canopy is not worked out in mango. However, light distribution within canopy is universally related with the foliage density. The paucity of information on the foliage component of mango cultivars is mostly because of non-availability of indirect canopy structure measurement technique and direct measurement technique being tedious and practically impossible for large mango tree canopy. The studies on relationship between leaf area index and light interception have been conducted in fruit trees by Heinicke (1973), Jackson (1970) and Verheij and Verwer (1973). Models and experimental data on light interception in orchards have demonstrated that dry matter and yield are proportional to total light interception, whereas fruit quality and flowering depends on light distribution within the canopy (Jackson, 1980, Robinson and Lakso, 1989, Jackson and Palmer, 1977). These studies have indicated the importance of indirect techniques, which are based on the closed coupling between light penetration and canopy structure. These alternative methods use canopy gap fraction at various angles (Norman and Campbell, 1989). Gap fractions have been measured by Fish Eye photograph (Anderson, 1971) and Linear light sensor (Walker *et al.*, 1988). However, other techniques like hemispheric photographs did not yield an accurate orchard LAI. Inaccuracies in gap sizes may result from subjective thresholding of photographs (Becker *et al.*, 1989).

Significant variability among Indian cultivars was observed in diffused non interceptance (DNI). Theoretically the quantity of this parameter may range between 0-1, which indicates the probability of diffused radiation from the upper hemisphere penetrating the canopy to the particular location. This parameter can be used as an index for studying light distribution within the mango canopy. The cultivars like Fernandin, Papatio, Malihabad Safeda and Rataul recorded high DNI values. Thus, the fruits and shoots developing in these canopies are more exposed to solar radiation and thus producing better coloured fruits and flowering shoots.

The study suggested that the cultivar with high foliage density and low DNI values can be modified by imposing pruning treatment. Pruning after harvest by removing growing shoots may be useful in improving DNI values.

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