CARIBBEAN FOOD CROPS SOCIETY

49

Forty-ninth Annual Meeting 2013

Port of Spain, Trinidad and Tobago
Vol. XLIX

PROCEEDINGS

OF THE

49TH ANNUAL MEETING

Caribbean Food Crops Society
49TH Annual Meeting
June 30 – July 6, 2013

Hyatt Regency Hotel
Port of Spain, Trinidad and Tobago

"Agribusiness Essential for Food Security: Empowering Youth and Enhancing Quality Products"

Edited
by
Wanda I. Lugo, Héctor L. Santiago, Rohanie Maharaj, and Wilfredo Colón

Published by the Caribbean Food Crops Society

ISSN 95-07-0410

Copies of this publication may be obtained from:

Secretariat CFCS
P.O. Box 40108
San Juan, Puerto Rico, 00940

or from:

CFCS Treasurer
Agricultural Experiment Station
Jardín Botánico Sur
1193 Calle Guayacán
San Juan, Puerto Rico 00936-1118

Proceedings of the Caribbean Food Crops Society. 49:267-277. 2013

EFFECT OF CULTIVAR ON LIGHT INTERCEPTION IN BREADFRUIT (*ARTOCARPUS ALTILIS*)

M. Gloster and L. B. Roberts-Nkrumah. Department of Food Production, Faculty of Food and Agriculture, The University of the West Indies, Trinidad and Tobago

ABSTRACT: Increasing interest in the commercial development of breadfruit as a crop for food and nutrition security in tropical areas requires that consideration be given to production systems. Traditionally, breadfruit has been grown on farms as a minor crop in mixed tree crop systems or as one or a few trees, mainly on the border of smallholdings. In both systems, the tree is planted at wide spacing because of the large size typical of breadfruit cultivars in the Caribbean, which limits pure stand production. New cultivars are now available and can be evaluated for their suitability for planting at closer spacings. Since flowering and consequently, fruit production in breadfruit appears to be influenced by light, it is important to assess the size of trees and their ability to intercept light. The objectives of this study were to determine the effect of cultivar on tree morphology and light interception, and leaf area index in juvenile breadfruit trees, determines the relationship between light interception, leaf area index and tree dimensions, and consider the implications for managing a pure stand breadfruit orchard. The study was conducted at the University of the West Indies field Station (UFS) at Valsayn, Trinidad, using five breadfruit cultivars in a pure stand planting of 22 trees. The cultivars were Ma'afala (M), White (W), Local Yellow (LY), Jamaican Maka (JM), and Breadnut (BN).Tree dimensions, including tree height, canopy depth and canopy width were measured and data on Leaf Area Index (LAI) and light interception were collected. The results showed that cultivar had a very highly significant ($p<0.001$) effects on LAI, but not on light interception ($p<0.164$). The information provided has implications for breadfruit tree and orchard management, and productivity in the Caribbean.

Keywords: *Artocarpus altilis*, cultivar, leaf area index, light interception.

Introduction

Currently in the Caribbean, there is an interest in expanding breadfruit (*Artocarpus altilis* Fosberg) for commercial production. Breadfruit is grown in traditional systems including backyards of homes, and in border planting or mixed cropping system on farms as a consequence, production is low. However, a key issue which is a limitation to production is tree height. McKenzie (2000, 195) reported that knowledge of those environmental factors to which breadfruit's vegetative and reproductive growth are most sensitive is essential to the commercial development of the crop.

Breadfruit, a tree of the tropical lowlands (Purseglove 1968, 380), grows best in humid climates (Singh 1963), it is fast growing (Morton 1987, 51), and attains height of 20 m or more at maturity (Purseglove 1968, 380). Roberts-Nkrumah (2004, 203), reported that the vigorous growth rate produces a very tall tree with a large canopy. This determines tree architecture, and height, which influences light interception and distribution by the canopy and is of interest in commercial breadfruit production. Mc Kenzie (2000, 197) indicated solar radiation was the environmental factor strongly associated with female inflorescence production and thus the maximum bearing potential of breadfruit. Similarly, Roberts-Nkrumah (2004, 201), indicated that fruit set distribution was influenced by uneven light interception by the canopy. Also, Roberts-Nkrumah (1997, 27) indicated that cultivar differences in fruit number and size, may be influenced by tree age, and environmental factors. However, they did not evaluate the amount of light interception and distribution in breadfruit's canopy. Canopy volume may suggest higher fruit number, however, the effect may not commutate yield, i.e. fruit number and fruit weight. These other information is required because differences may have implications interception and spacing. Therefore, any effort towards increasing commercialisation of breadfruit will have to consider cultivar and light management. A preliminary study was conducted to determine effect of cultivar on the amount of light interception in breadfruit. The objectives were to (1) determine the effect of cultivar on tree dimension, (2) determine the effect of cultivar on leaf area index, (3) determine the effect of cultivar on percentage light interception in juvenile breadfruit trees, and (4) determine the relationships between leaf area index, light interception, and tree dimension. Also, the implications of light interception and leaf area index for tree, and orchard management, and productivity will be discussed.

Materials and Methods

The study was conducted on a pure stand breadfruit planting established located at the University of the West Indies Field Station (UFS), Valsayn, Trinidad. The plot consisted of five (5) breadfruit cultivars: 'Yellow', 'White', 'Ma'afala', 'Macca', and 'Breadnut' (*Artocarpus camansi* Blanco), planted in two rows with an east-west orientation, at 6 m (20 ft) within row (WR) and 3 m (10 ft) between row (BR) spacing, in a triangular plant arrangement. Measurement of tree dimension was done for tree height (TH), canopy height (CH), whorl number (WN), branch number (BN), canopy depth (CD), canopy width (CW), and tree girth (TG). Light interception (LI) and leaf area index (LAI) data were measured with an AccuPAR PAR/LAI Ceptometer (Model LP-80, Decagon Devices, Inc., Pullman, WA 99163). Data analysis was done using Computer Software Minitab version 16. ANOVA One way analysis was used to determine significant differences among main effects, and Tukey's Method was used for grouping, pair wise comparisons, and to determine significant differences among means. Regression analysis and Pearson's correlation coefficient were used to determine relationship among variables.

Results

Effect of Cultivar on Tree Dimension

The results of this study showed that in juvenile breadfruit, differences in tree dimensions were highly significant among cultivars in tree height, canopy height, whorl number, and branch number, but not canopy depth, canopy width, and tree girth (Table 1). Among cultivars, overall mean tree height was 5.5 m, and was significantly different between ‘Breadnut’ a seeded breadfruit specie and all other cultivars except ‘Ma’afala’. Canopy height differences were significant among ‘Breadnut’, ‘White’ and ‘Macca, but not ‘Yellow’ and Ma’afala, with an overall mean of 0.9 m. Similarly, mean whorl number was significantly different between ‘Macca’, which had the highest whorl number, and ‘Breadnut’, which had the lowest whorl number, but not among the other cultivars. The overall mean whorl number among cultivars was five. Mean branch number was significantly different among cultivars. ‘Ma’afala’ had the highest branch number, while ‘Breadnut’ had the lowest. Also, branch number in all the cultivars were significantly different than in ‘Breadnut’. Overall, mean branch number per cultivar was 33 branches.

Table 1. Effects of cultivar on breadfruit tree dimensions at UFS, Trinidad, 2013.

Cultivar	N	Tree height (m)	Canopy height (m)	Whorl No.	Branch No.	Canopy depth (m)	Canopy width (m)	Tree girth (m)
Ma’afala	4	5.7ab	0.7bc	5ab	30a	4.7a	5.2 a	0.13a
Macca	5	4.9b	0.4c	6a	27ab	4.4a	5.7 a	0.2a
Yellow	3	5.6b	0.9abc	4.3ab	21bc	3.6a	5.1 a	0.2a
White	5	4.9b	1.0ab	5ab	20.6c	4.0a	5.3 a	0.14a
Breadnut	5	6.3a	1.3a	4b	14d	5.1a	5.3 a	0.2a
Mean		5.5	0.9	5	22	4.4	5.3	0.2
P<0.05		0.004	0.003	0.04	0.001	0.16	0.902	0.128

Means that do not share the same letter within a column are significantly different.

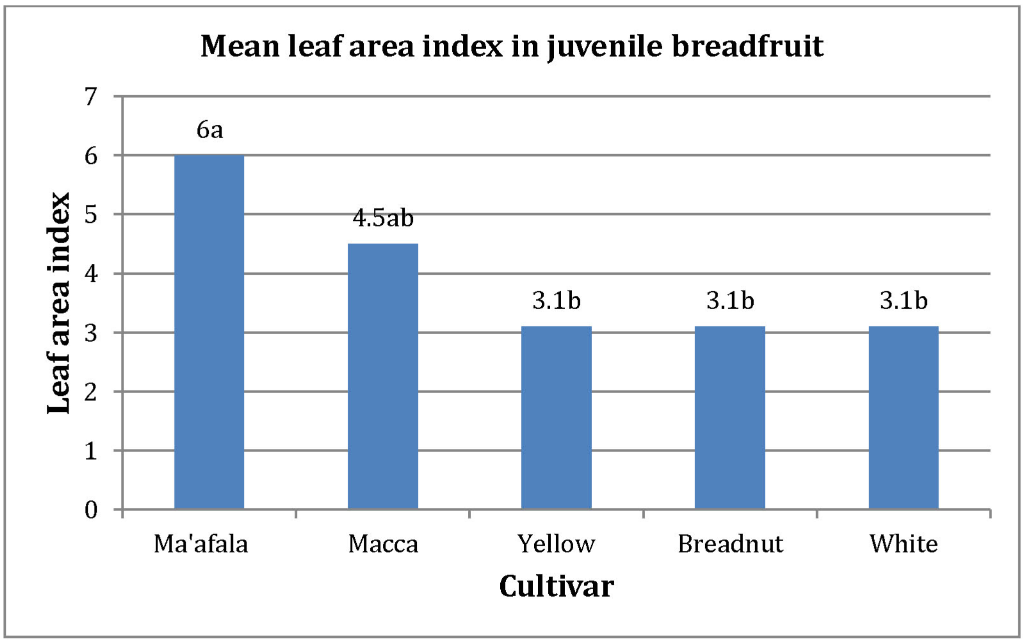

Figure 1. Effect of cultivar on leaf area index in juvenile breadfruit trees at UFS, Trinidad. Means that do not share a letter are significantly different.

Effect of Cultivar on Leaf Area Index (LAI)

Differences in Leaf area index (LAI) among breadfruit cultivar were highly significantly different ($p<0.001$). Also, mean leaf area index was significantly different among cultivars. Mean leaf area index for all cultivar was 4.0 (Figure 1).

Effect of cultivar on amount of light interception (LI)

Differences in percentage light interception was not significant ($p<0.164$) among breadfruit cultivars. Also, mean percentage light interception was not significantly different (Figure 2).

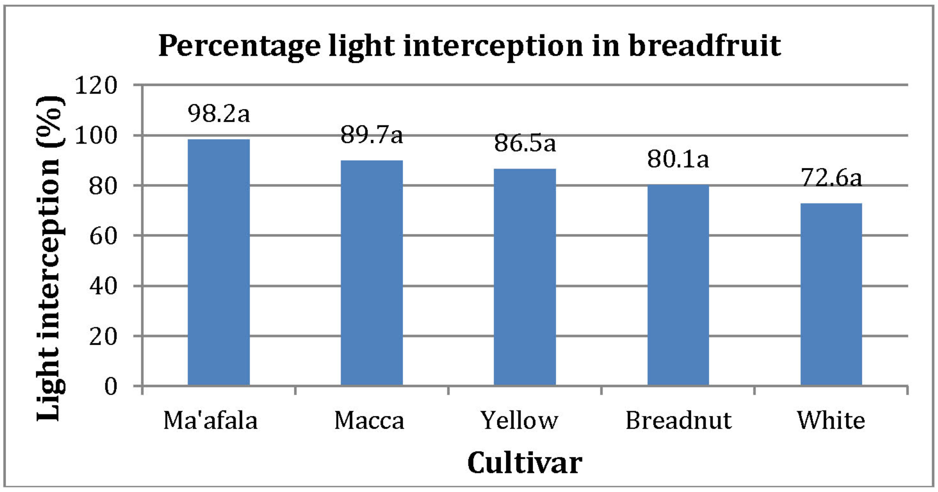

Figure 2. Cultivar effect on amount light interception in breadfruit. Means that do not share a letter are significantly different.

Relationship Between LAI and Tree Dimensions

Only those relationships which are significantly different are reported.

Relationship Between LAI and Branch Number

LAI was highly significant ($p<0.001$), and strongly, positively linearly related to branch number in breadfruit (Figure 3).

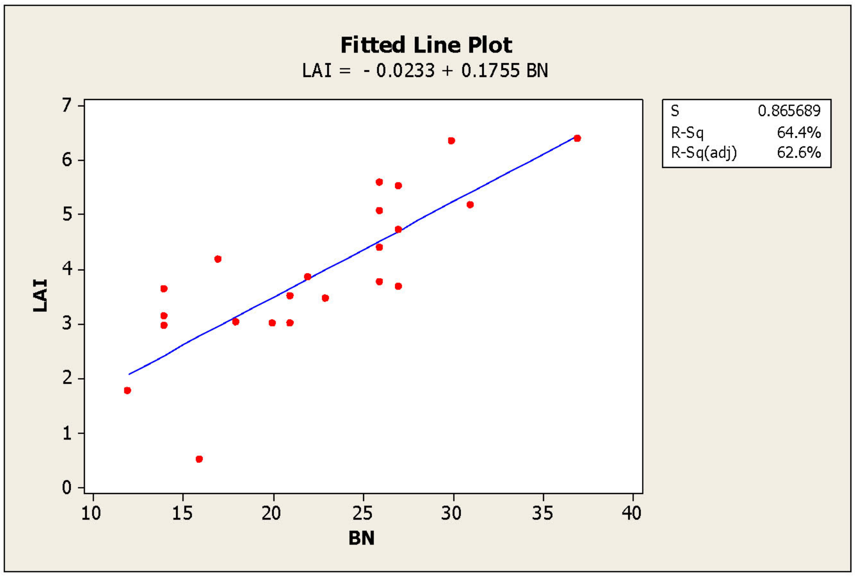

Figure 3. Relationship between LAI and branch number in juvenile breadfruit trees at UFS, Trinidad.

Relationship Between LAI and Canopy Height

LAI was highly significant ($p<0.008$), and weakly, negatively linearly related to canopy height in breadfruit (Figure: 4).

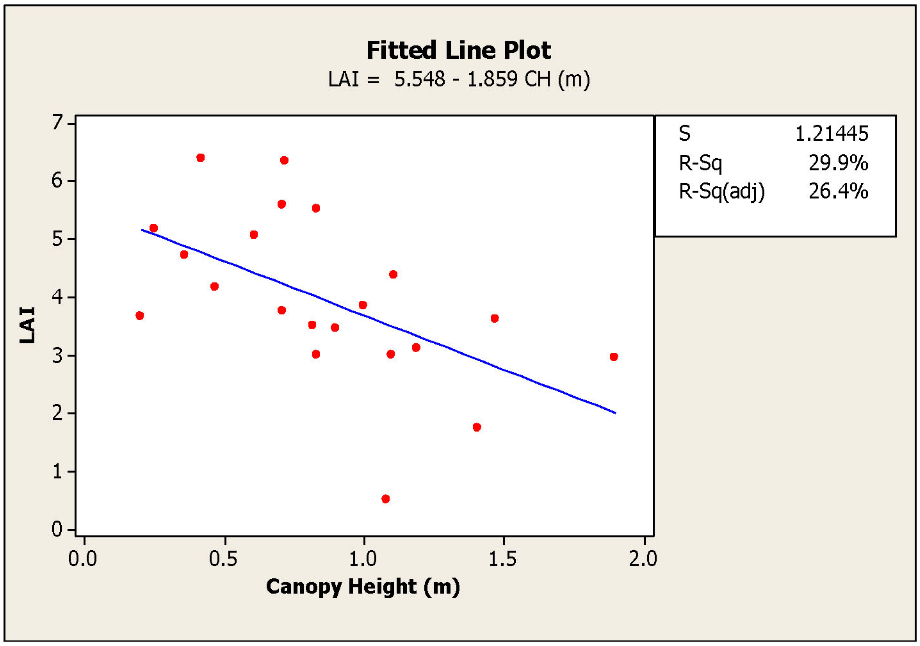

Figure 4. Relationship between LAI and canopy height in juvenile breadfruit trees at UFS, Trinidad.

Relationship Between LAI and Whorl Number

Relationship between LAI and whorl number was highly significant ($p<0.015$), but weakly, and positively linearly related in breadfruit (Figure 5).

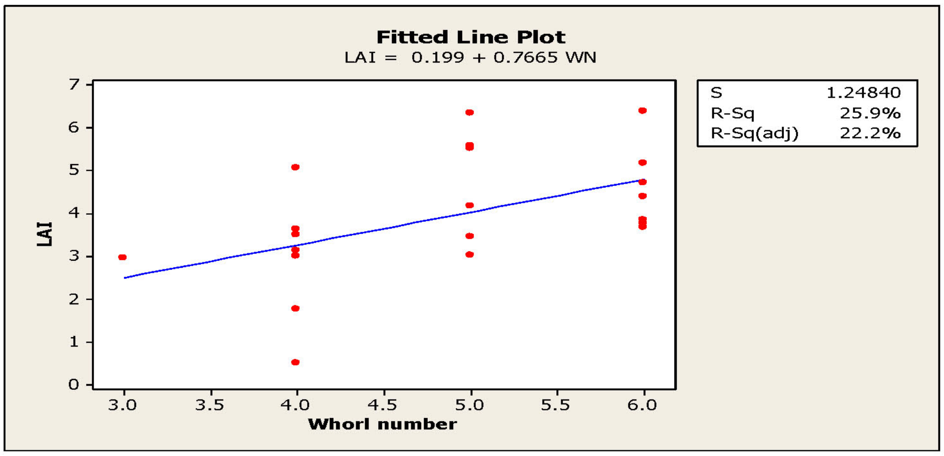

Figure 5: The Relationship between LAI and world number in juvenile breadfruit trees at UFS, Trinidad.

Relationship Between Amount of Light Interception and Tree Dimensions

Only those relationships which are significantly different are reported.

Relationship Between Light Interception and Canopy Width

Percentage light interception was highly significant ($p<0.018$), but weakly and positively linearly related to canopy width (Figure 6).

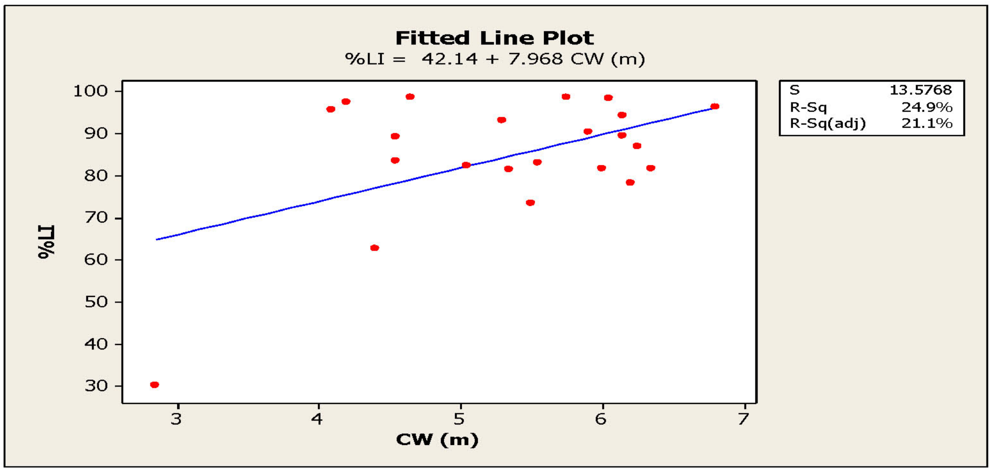

Figure 6. Relationship between light interception and canopy width in juvenile breadfruit trees at UFS, Trinidad.

Relationship Between Percentage Light Interception and Branch Number

Relationship between percentage light interception and branch number was highly significant (p<0.005), and weakly positively linearly related (Figure 7).

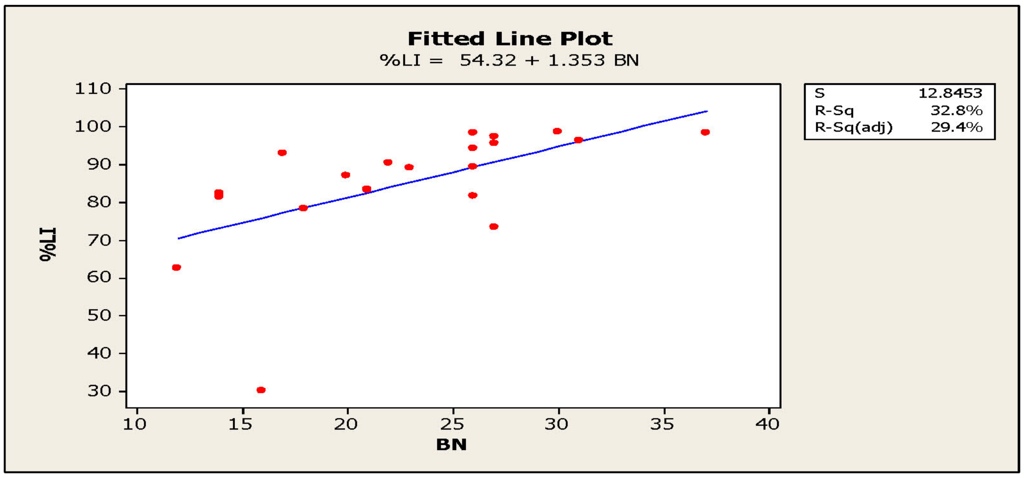

Figure 7. Relationship between percentage light interception and branch number in juvenile breadfruit trees at UFS, Trinidad.

Relationship Between Light Interception and Leaf Area Index

Relationship between light interception and LAI was very highly significant (p<0.001), and very strongly, positively linearly related.

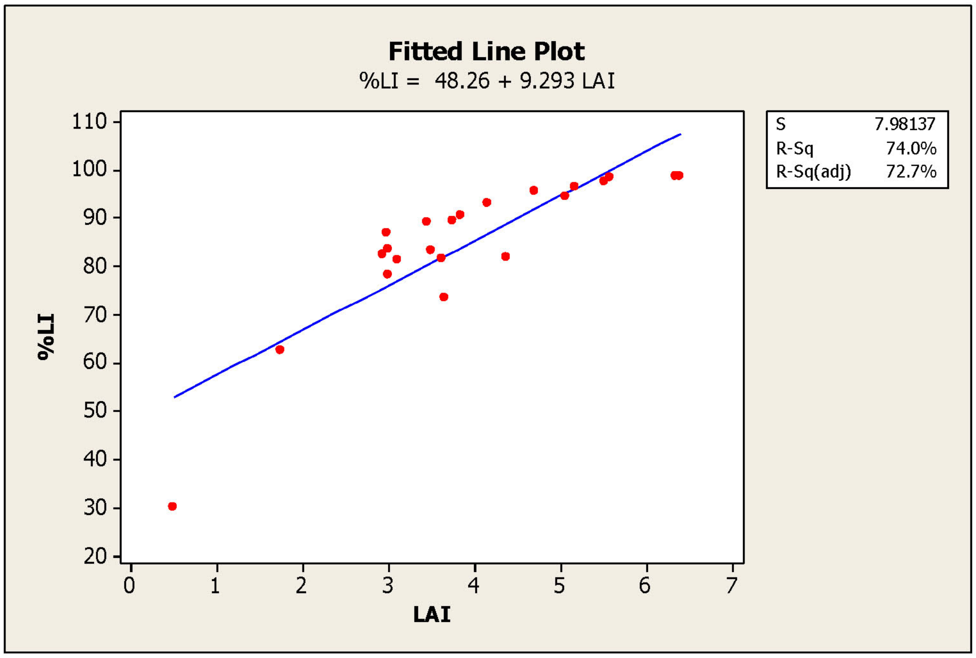

Figure 8: Relationship between percentage light interception and leaf area index in juvenile breadfruit trees at UFS, Trinidad.

Correlation Between Leaf Area Index and Tree Dimension

Only those correlations which are significantly different are reported.

Leaf area index was highly significant ($p<0.001$), and strongly positively correlated to branch number and whorl number, but strongly negatively to canopy height ($r = 0.802$, $r = 0.509$, and $r = -0.547$), respectively.

Correlation Between Light Interception and Tree Dimensions

Percentage light interception was highly significant, and moderately positively correlated to canopy width and branch number ($r = 0.499$ and $r = 0.572$), respectively.

Correlation Between Leaf Area Index and Light Interception

Percentage light interception and leaf area index highly significant, and strongly positively correlated ($r = 0.861$).

Discussion

Highly significant differences of breadfruit tree dimensions were because of cultivar and species differences in tree height, canopy height, whorl number, and branch number, but not canopy depth, canopy width, and tree girth.

Highly significantly different in leaf area index was mainly because of cultivar morphological differences of tree height, canopy height, number of whorls and number of branches. 'Ma'afala', a cultivar with a dense canopy, had a significantly higher LAI than all other cultivar with a less dense canopy. Also, overall, leaf area index among breadfruit cultivar was high, which is an indication of breadfruit high requirement for light.

Percentage light interception, which is the amount or percent total available light intercepted by the fruit tree canopy, and which does not strike the orchard floor, and relates to flower formation, fruit set, fruit development, and quality (Rom and Barritt 1987, 42), was not significantly different among breadfruit cultivar. However, among cultivars, 'Ma'afala' had the highest light interception, and 'White had the lowest'. The high light interception in Ma'afala was because of short tree height, low canopy height, high whorl number, and branch number, which were efficient in maximizing interception of incoming radiation, compared to the other cultivars. Generally though, the amount of light interception among breadfruit cultivar was very high, 73-98.5 percent, and exceeds the range of 70 % and 80 % proposed by Iyer and Kurian (2006, 61) for optimised tree management and fruit production. Also, this supports findings by Roberts-Nkrumah (2004, 203), that breadfruit, as a species, has several morphological characteristics that indicate its high light requirement.

Leaf area index was linearly dependent on the amount of light interception. Therefore, as leaf area index increases, the percentage light interception increases, and visa verse. A high level of light interception can be achieved with a, closed canopy (Iyer and Kurian 2006, 63). Therefore; this relationship has implication for breadfruit productivity.

Strong positive correlation between leaf area index and tree dimension was because of strong association between branch number and whorl number. However, leaf area index and canopy height were negatively correlated. Therefore, breadfruit trees with high leaf area index had high branch number and whorl number. However, trees with high canopy height, tends to have low leaf area index.

Percentage light interception was positively correlated with tree dimension of branch number and canopy width. Therefore, there was a strong association between percentage light interception and branch number and canopy width. Breadfruit trees with high percentage light interception had high branch number and wide canopy width.

Strong positive correlation between percentage light interception and leaf area index indicated that in breadfruit, percentage light interception was strongly associated with leaf area index. Therefore, tree with high percentage light interception tends to have high leaf area index.

Overall, these results have several implications for breadfruit tree and orchard management, and productivity. Firstly, they showed that among breadfruit cultivars, differences in trees dimensions were highly significant. Therefore, for orchard establishment and management emphasis must be placed on selecting cultivars with tree dimension such as short tree height, and canopy height, and high whorl number, and branch number. Secondly, breadfruit was highly efficient in percentage light interception, but among cultivars, the amount intercepted was not significantly different. However, there was a direct relationship between light interception and canopy width and whorl number. As a consequence, breadfruit has the capacity for accumulation of large amount of dry matter which is important from a management stand point for vegetative and reproductive growth, hence greater productivity. This supports Rom and Barritt (1987, 42), report that orchard productivity is related to the amount of light intercepted by the orchard, therefore, light interception should be maximised early in the life of the orchard in order to maximised production by the tree. Therefore, for tree and orchard establishment, and management, cultivars should be manipulated by management practices such as pruning to increase efficiency of the distribution of the incepted light within the tree canopy. Thirdly, these results highlighted the highly significant, strongly positive, and negative correlated linear relationship between leaf area index, percentage light interception, and tree dimensions. Therefore, understanding and managing these will result in greater lighter interception in the canopy, hence greater productivity. This confirmed to report by Iyer, and Kurian (2006, 60) that high yield, and high fruit quality comes from combining good light distribution and in the canopy and high light interception. In managing these relationships in a pure stand breadfruit orchard, emphasis must be on strategies that will increase light interception, such as site selection, cultivar selection, tree population, tree spacing and arrangement, and pruning, which will result in an increase in leaf area index. Fourthly, these results will facilitate for greater productivity in breadfruit orchards because they gives a better understanding of the significant effect of cultivar on light interception which will allow for greater tree and orchard management. Rom, and Barritt (1987, 54) reported, when light is limiting, and presumably, photosynthesis is reduced, the tree balances itself by reducing crop load via fewer flowers and fruit.

Conclusion

The study showed that tree dimensions were significantly different among breadfruit cultivars. Also, cultivar had a significant effect on leaf area index, and percentage light interception by the canopy. Both leaf area index and light interception were significantly influenced by cultivar. Relationship between tree dimensions, leaf area index, and light interception were linearly and correlated for canopy height, whorl number, branch number, and canopy width and branch number, respectively. As a consequence, these have implications for light interception, tree management and productivity of breadfruit. Therefore, further studies will be necessary to evaluate strategies for increasing amount of light interception among breadfruit cultivars, and to evaluate the effect of light management on productivity of breadfruit.

Acknowledgement

Sincere thanks to the Department of Food Production, Faculty of Food and Agriculture, The University of the West Indies, St. Augustine Campus, for proving funding for attendance at Caribbean Food Crops Society Conference 2013 in Trinidad.

References

Deivanai, S., and Subhash J. Bhore. 2010. Breadfruit (Artocarpus altilis Fosb.) An Underutilized and Neglected Fruit Plant Species. *Middle-East Journal of Scientific Research,* 6 (5): 418-428.

Lyer, C. P. A., and Reju M. Kurian. 2006. *High Density Planting in Tropical Fruits*: Principles *and Practices*. Lucknow, India: International Book Distributing Co.

Marini Richard P. 2009. “Training and Pruning Apple Trees.”*Virginia Cooperative Extension*, May 1.

Mc. Kenzie, Carol-Anne. 2000. “Breadfruit (*Artocarpus altilis*. Fosberg) Phenology and Growth Responses to Selected Plant Growth Regulators.” MPhil’s thesis. The University of the West Indies, St. Augustine, Trinidad and Tobago.

Morton, J. 1987. Breadfruit n . *Fruit of warm Climates*. Miami, Fl.

Purseglove, J.W. 1966. Tropical Crops Dicotyledons.

Roberts-Nkrumah, L. B. 2004. “Management Implications of the Distribution of Fruit Set on Breadfruit” (Artocarpus altilis) Trees*. ISHA Acta Horticulturae* (632): ISHS.

Roberts-Nkrumah, Laura. 1997. “Towards a Description of the Breadfruit Germplasm in St Vincent.” *Fruits* 52: 27-35.

Rom, Curt. R, and Bruce H. Barritt. Light Interception and Utilization in Orchards

Turner, D. W. 1986. Plant Carbon Balance. *Acta Horticulturae* (175): 109-114.

Wheaton, T. A., W. S, Castle, J. D. Whitney, and D. P. H Tucker. I991. Performance of Citrus Scion Cultivars and Rootstocks in a High Density Planting. *HortScience*, Vol. 246 (7).
Whiley, A. W., and B. Schaffer. 1997. "Stress Physiology." In *Mango Botany Production and Uses*, edited by Richard E. Litz, 147-173. New York: CAB International.