INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 21, No. 5, p. 56-63, 2022
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Breadfruit [*Artocarpus altilis* (Parkinson) Fosberg] propagation using root cuttings treated with rooting hormones

Ida Variacion-Maghuyop*

Department of Environmental Science, College of Forestry and Environmental Science, Central Mindanao University, Musuan, Bukidnon, Philippines

Article published on November 10, 2022

Key words: Agroforestry, Breadfruit, Food security, Planting stock, Propagation

Abstract

The study aimed to assess the root and leaf emergence performance of breadfruit root cuttings under different concentrations of rooting hormones. A two-factor experiment in split-plot experimental design was used in the analysis. Rooting hormones corresponding to Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) were the main plot factor (factor A) and the hormone concentration at three different levels as the subplot factor (factor B). The treatments or factors were replicated three times with ten samples per subplot. It revealed that the number of leaf emergence was significant under factor A. Number of leaf emergence was also significantly different between levels under factor B. Post hoc analysis showed that control obtained the highest mean of 2.78. In terms of root emergence, factor A showed significant results while factor B was not significant. A significant difference was also observed between treatment means. The number of root emergence was highest in the control with a mean of 2.57 and is significantly different from the two growth hormones. Highly significant difference between treatments on the survival of cuttings with control having the highest mean of 54.44%. Overall, result revealed that the emergence of leaves and roots of breadfruit from root cuttings was not influenced by rooting hormones under non-mist propagation. Breadfruit can easily propagate using root cuttings even without the use of growth hormones.

***Corresponding Author:** Ida Variacion-Maghuyop ✉ ivmcfes@cmu.edu.ph

Introduction

An estimate of more than 80% of the world's hungry people live in the tropical and subtropical regions, the same regions where breadfruit can be grown. Hunger in these tropical regions creates periods of increased global food insecurity (Turi *et al.*, 2015). At this critical time of food security issues, many alternatives to fight hunger have been explored to provide a solution to end the crisis. Along with this context, breadfruit, known as food for the future is said to be the new potential solution to hunger in the tropics (Ragone, 2018; Jones, *et al.*, 2011). Breadfruit could also help in solving malnutrition problem (Olatunya *et al.*, 2017). It continues to expand into the global tropics as a productive and nutritious food crop (Needham, *et al.*, 2020). The plant has many other potential uses that make it the subject of experimental studies in the search for drugs and medicines (de Souza *et al.*, 2016; Englberger *et al.*, 2014). The different uses of the fruit of breadfruit including its botanical description are discussed in the work of Tamegnon *et al.* (2017).

Studies of breadfruit have been conducted in other countries, but in the Philippine setting, literature has yet to be published. Future research and development studies on breadfruit propagation are hoped to expand to help and guide potential breadfruit-growing countries in planning and implementing projects for this bread-like fruit tree (Muller, 1991).

Although pertinent and concerned government agency is putting up nurseries for breadfruit plantation establishments, many small-scale farmers still lack access to good-quality planting materials to cultivate the plant. Lucas and Ragone (2012) assert that limited availability and a lack of access to planting material of good quality have been major impediments to integrating breadfruit in agroforestry programs and projects. FARC (2012) also reported that the genetic erosion of many clonally propagated traditional crops, including breadfruit, is a serious problem in the Pacific Islands. Breadfruit propagation is indeed a challenge (Nickum, 2013).

Locally known as "Rimas" in the Philippines, the plant is usually grown using root cuttings. This is commonly the most preferred and the most economic method because it involves a shorter duration of producing planting materials. The problem lies in very low undesirable percentage of success (Siddiqui & Hussain, 2007). Thus, the application of root-promoting hormones is seen to hasten root propagation from the cuttings. As reported, breadfruit planting stocks can be produced from root cuttings induced with rooting hormone to produced adventitious shoots (Roberts-Nkrumah, 2015). According to Barbeau (1992), the application of growth hormones like Indole Butyric Acid (IBA) or Naphthalene Acetic Acid (NAA) at the base of the cuttings will help to improve greatly the rooting percentage and the number of roots per cutting.

This study aimed to assess the responses of breadfruit root cuttings treated with two kinds of rooting hormones at different levels of concentration. Results of the study would provide relevant information on the production of planting materials of breadfruit using root cuttings. This study would eventually help local tree growers to mass-produce breadfruit trees out of the root cuttings.

Materials and methods

Location of the Study

The study was conducted at the nursery area of the College of Forestry and Environmental Science in Central Mindanao University, Bukidnon, Philippines. The site has an elevation of 200 to 260 meters above sea level. The observation area was partially shaded due to the presence of isolated trees, shrubs and other vegetation in the surroundings. It also receives an adequate amount of sunlight suitable for the propagation of breadfruit cuttings.

Experimental designs and treatment

The study was conducted using a two-factor experiment in split-plot design. The treatments consisted of the three rooting hormones as the main plot factor (Factor A) with three levels of hormone concentration as the subplot factor (Factor B).

The treatments were replicated three (3) times with ten (10) sample root cuttings per subplot. Factor A included the control (without hormone), indole butyric acid (IBA) and naphthalene acetic acid (NAA), symbolized as H_1, H_2, and H_3, respectively. Factor B included hormone concentrations with 100 milligrams per liter (mg/L), 500mg/L, and 1000mg/L, symbolized as C_1, C_2, and C_3, respectively. Fig. 1 shows the lay-out of the experiment in split-plot design. The variables considered in the study included the five propagation responses namely; the number of leaves, length of leaves, number of roots, length of roots and survival rates.

R_1 →	H_1C_3	H_1C_1	H_1C_2	H_3C_3	H_3C_2	H_3C_1	H_2C_1	H_2C_2	H_2C_3
R_2 →	H_2C_3	H_2C_1	H_2C_2	H_3C_1	H_3C_3	H_3C_2	H_1C_2	H_1C_1	H_1C_3
R_3 →	H_1C_2	H_1C_3	H_1C_1	H_3C_1	H_3C_2	H_3C_3	H_2C_2	H_2C_3	H_2C_1

Fig. 1. Lay-out of the experiment in split-plot design. H_1 = control, H_2 = IBA, H_3 = NAA, C_1 = 100mg/L, C_2 = 500mg/L, and C_3 = 1000mg/L.

Collection and preparation of root cuttings

The healthy mother trees from the field with an approximate average age of eight years old were arbitrarily selected as the source of the root cuttings. The collection was done early in the morning to minimize transpiration. The roots of the selected breadfruit trees were carefully excavated (Fig. 2) two to three meters away from the tree trunk and extraction was done all at the same time in the 3 mother trees. Breadfruit roots tend to spread and intermingle with those of adjacent trees so a root was followed back to the source tree to make sure it is from the desired breadfruit tree. Vigorous, healthy and undamaged tree roots with an average diameter of 1.8cm were selected. Surface roots were not used because they tend to dry out and are less successful.

The root cuttings were thoroughly washed to remove soil and any damaged pieces were discarded. It was then cut into sections at an average of 22.2cm in length. The roots were then treated with fungicide (30mL in 16 L water) and soaked for one hour to prevent the growth of pathogens that may cause root rot and to avoid contamination.

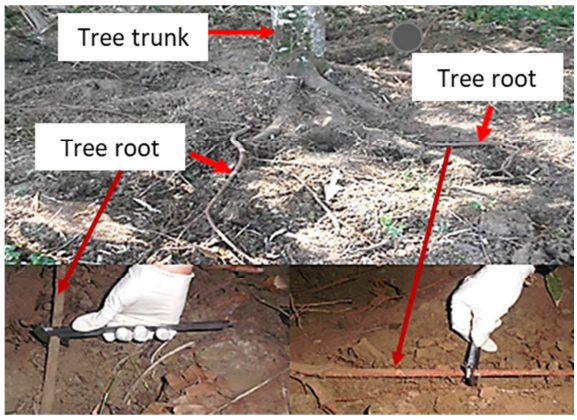

Fig. 2. Excavation of root cuttings for propagation experiment.

Setting the root cuttings for propagation

The styrofoam boxes measuring 9.4 x 6.7cm were prepared by putting approximately 100 kilograms of treated fine sand. The sand was watered thoroughly in preparation for the planting. The treatments were assigned at random by drawing lots. Root cuttings were spaced 10cm apart in a row and 15cm between rows in the box. Cuttings were placed at an angle but not upright with the small upper portion of the root exposed. The boxes were then covered with transparent plastic cellophane. Root cuttings were kept shaded up to 60% shade and moist, but not wet. The non-misting propagation technique was used.

Data gathering and analysis

Number of leaves was obtained by counting the number of emerging leaves in each cutting. The average length of leaves was obtained by measuring the total length of leaves divided by the number of leaves in a cutting. The number of roots was obtained by counting the roots that emerged in each cutting. The average length of roots was obtained by measuring the length of each root in a cutting divided by the number of roots in a cutting. Rooting percentage was obtained by counting the number of cuttings that rooted by the total number of cuttings planted multiplied by 100. Number of days to shoot emergence was recorded the first time a shoot

appeared which was 4 weeks and every ten days thereafter. Data was gathered upon termination of the study except for the number of days to shoot emergence. Analysis of Variance (ANOVA) was employed using the statistical computer software program. Comparison among treatment means was done using Tukey's w-procedure.

Results and discussion

Table 1 is the summary of results of the ANOVA showing the main plot (Factor A) or rooting hormone means of the different propagation responses. Similarly, Table 2 is the summary of results of the ANOVA showing the subplot (Factor B) or the level of hormone concentration means of the different propagation responses.

Table 1. Rooting hormones (Factor A) means of propagation responses.

Rooting Hormones (Factor A)	Responses				
	a	b	c	d	e
H_1 (control)	2.78^a	2.44	6.77^a	2.57^{ab}	54.44^a
H_2 (IBA)	0^b	0	1.37^b	0.74^b	10.00^b
H_3 (NAA)	0^b	0	2.87^b	4.02^a	50.00^{ab}

Note: Means of the same letter in a row are not significantly different from each other

a = number of leaves

b = length of leaves

c = number of roots

d = length of roots

e = survival rates in percent

Table 2. Level of concentration (Factor B) means of propagation responses.

Level of Concentrations (Factor B)	Responses				
	a	b	c	d	e
C_1 (100)	0.78	1.02	4.73	3.40	55.56^a
C_2 (500)	0.44	0.38	2.83	1.63	30.00^b
C_3 (1000)	1.56	1.03	3.46	2.30	28.89^b

Note: Means of the same letter in a row are not significantly different from each other

a = number of leaves

b = length of leaves

c = number of roots

d = length of roots

e = survival rates in percent

Leaf emergence responses

For the number of leaves, control has the highest mean of 2.78 while IBA and NAA has no data since they did not produce leaves throughout the duration of the study. This demonstrates to what Cadiz *et al.* (2013) emphasized that once the cuttings produced roots, the formation of shoot will follow soon or even much later. However, in some instances, the formation of shoots takes earlier than the formation of roots. It happens when cutting materials are taken from the cuttings with higher nitrogen content than carbohydrates. Dagatan (2007) reported that the endogenous hormones and the stored foods within the cuttings serve as the nutrient pool which were used by the cuttings in the production of leaves.

Root cuttings must initiate a new shoot system from an adventitious bud (Hartmann, 1975). Production of adventitious roots must take place in root cuttings. Bud initiation on root pieces is stimulated by cytokinins. On the other hand, auxins tend to inhibit shoot formation on root cuttings. It was assumed that hormone-like substances were formed in the developing buds and transported through the phloem to the base of the cutting, where they stimulated root formation. It has long been known that the presence of leaves on cuttings exerts a strong stimulating influence on root initiation. The rooting factors provided by the leaves or buds could perhaps stimulate rooting. In addition, Hartmann (1975) stated that carbohydrates translocated from the leaves, undoubtedly contribute to root formation. However, the strong root-promoting effects of leaves and buds are due probably to other more direct factors. Leaves and buds are known to be powerful auxin producers, and the effects are observed directly below them, showing that polar apex-to-base transport is involved.

This study implies that the cuttings under the control have a sufficient amount of auxins in their leaves, and the application of rooting hormones may have contributed to the inhibition of root formation of most of the cuttings applied with IBA and NAA. Apparently, at the end of the study, the uprooting of

cuttings with leaves during data gathering has shown that the roots were healthy and vigorous. As presented earlier, only control has demonstrated leaf production in contrast to IBA and NAA which have shown no signs of leaf initiation.

For the length of leaves, there is no significant difference among treatments. Rooting hormones and their concentrations did not influence the mean length of leaves. Shown in Table 1, the highest mean was that only of control which has a mean of 2.44cm. Since control has the highest mean on the number of leaves, it followed that it has the highest mean on the length of leaves. IBA and NAA also has 0 means corresponding to the number of leaves, since there was no data during the whole duration of the study. Variation among means was found not significantly different from each other.

Root propagation responses

Significant difference was found between IBA and NAA and their interaction for the number of roots propagation response. NAA is proven to have better results in rooting compared to that with IBA. Some of the cuttings belonging to IBA produced roots but very minimal compared to that of control. Previous studies showed that the application of rooting hormones significantly increases the rooting rates of particular species (Cadiz *et al.*, 2013). IBA was found to be more effective to some species compared to other auxins, but is not true to all species. Particular species react differently to different concentrations of auxins. Tare (2013) recounted that root cuttings have natural auxins which are good enough to develop roots as exhibited in the control in this experiment. In comparing the treatments, control is significantly different from IBA and NAA but both hormones are not significantly different from each other. The presence of leaves would render the plants to manufacture more roots, since control has the highest mean in terms of the number of leaves, it follows that it is more responsive to rooting. IBA concentration just below the toxic level is best for root production (Hocking & Thomas, 1979). In this study, even 100mg/L concentration (Table 2) of IBA did not show considerable results. It is assumed that a concentration lower than 100mg/L IBA may increase rooting of breadfruit cuttings.

The average number of roots that formed in response to control, IBA and NAA showed a significant difference. However, no significant difference was found between IBA and NAA and their interaction. Results from previous study showed that NAA was proven to have better results in rooting compared to that with IBA (Dagatan, 2007). In this case, NAA also shows better results compared to that of IBA. Cadiz *et al.* (2013) disclosed that some cuttings root with difficulty and do not respond well to hormones. Certain factors such as the type of wood, stages of growth and the condition when the cuttings are taken, must be considered to attain satisfactory rooting of cuttings. Some cuttings root easily and some plants cannot produce roots from cuttings. In this study, some of the cuttings belonging to IBA produced roots but very minimal compared to that of control.

The average length of roots that were formed also showed significant difference with control, IBA and NAA but is not significantly different with the concentration of the hormones. Comparison of means indicates that control has no significant difference with IBA and NAA but both the hormones are significantly different from each other. On the other hand, concentrations of rooting hormones did not influence length of roots. Variation among means was found non-significant and no interaction effects were noted on rooting hormones and concentrations. Dagatan (2007) reported that cuttings treated with NAA had yielded higher mean length of roots (0.93cm) than the cuttings treated with IBA with a mean of 0.57cm. Growth regulators may alter the type of roots formed as well as the quantity grown. IBA produces a strong fibrous root system whereas NAA often produces a bushy, but stunted root system. The roots presented in Fig. 3 shows the difference in length of roots and structures of rooted cuttings of control (H_1), IBA (H_2) and NAA (H_3) in conjunction with this study. It can be seen in all the three treatments that the roots illustrate a difference in root

system. Control shows the root system of breadfruit, while IBA is showing signs of a thin root system in a cutting that is less likely to survive, and NAA as mentioned has a bushy root system. This shows that IBA is not well suited for the crop in terms of rooting.

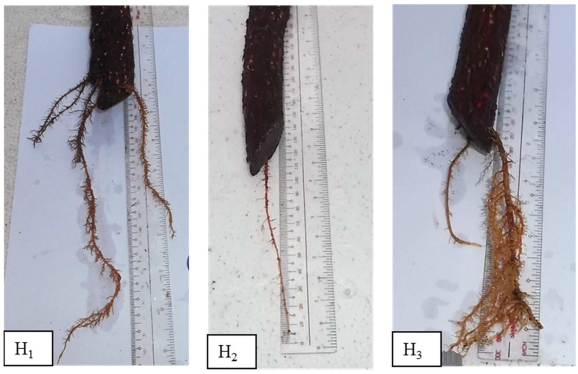

Fig. 3. Rooted cuttings of breadfruit in response to different treatments.

Survival rates

For the survival rates, comparison of means indicate that control is significantly different from IBA but not significantly different from NAA while NAA is not significantly different from control and IBA. Though IBA has been found more effective to some species than other auxins like NAA, this might not be true to all species (Cadiz 2013), and that includes breadfruit. In terms of the concentrations, 100mg/L is significantly different from 500mg/L and 1000mg/L. However, the last two concentrations (500mg/L and 1000mg/L) are not significantly different from each other. The use of 100mg/L rooting hormone is favorable especially with the use of NAA. No significant difference, however, was found on the interaction of the treatments with the concentrations. The results emphasize that the root cuttings of breadfruit do not need hormones to enhance rooting. If hormones will be used, NAA will probably give better results. IBA was found more effective to some species than other auxins but not in the case of breadfruit. Moreover, the lower rooting percentage of 1000mg/L, may be attributed to the higher concentration of the rooting hormones not tolerable by breadfruit. As found in the results, breadfruit cuttings do not need rooting hormones to enhance rooting. Another contributing factor for the low survival rate of cuttings in this study is that the cuttings used in the study were leafless. Previous studies showed that most species of trees can be rooted with leafy cuttings, but not so many will root from leafless cuttings (Longman, 2002). Moreover, Dagatan (2007) emphasized that leafless cuttings do not root and that one whole leaf should be retained on each cutting to provide some current photosynthates for root development and that rooting percentage is high with leafy cuttings. It is clear in this study that root cuttings are used and not root shoots, therefore contributing to the fact that survival is minimal.

Shoot Emergence

First appearance of shoots was observed four (4) weeks after planting. As depicted in Fig. 4, control (H_1) has the highest number of shoot emergence with 48 cuttings, from 30 days to 150 days. The graph shows a cumulative number of shoots that emerged from the cuttings until the end of the study. However, IBA (H_2) presented zero (0) shoot emergence from the cuttings and NAA (H_3) only showed one (1) shoot emergence from the cuttings for the whole duration of the study. According to Hartmann (1975), root cuttings of some species form a strong adventitious shoot, but no new roots develop and the cutting eventually dies. In certain species, root cuttings will produce a strong new root system but no adventitious shoots arise, so the cutting finally dies. Apparently, based on the results, control has a greater chance of developing leaves and roots in response to shoot emergence in a period of 150 days. However, a valid inference cannot be generated since the data taken on days to shoot emergence of IBA and NAA are not reliably available. This will only show the trend of the treatments.

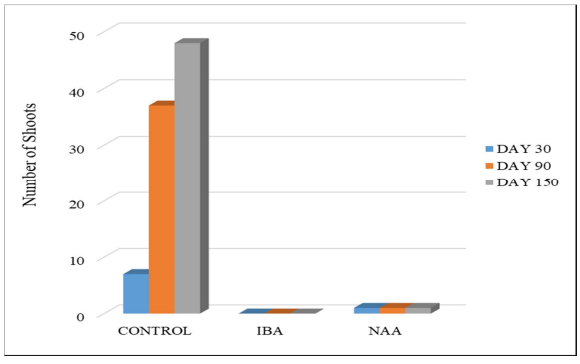

Fig. 4. Shoot emergence of treatments.

Conclusion

IBA and NAA have not shown significant difference compared to that with control. Hormone treatment, therefore, is not required in the propagation of breadfruit root cuttings, but the use of NAA has promising results. The use of 100mg/L concentration for NAA has shown to be more effective in enhancing rooting of breadfruit root cuttings compared to IBA. Control or no rooting hormone is best for the rooting and enhancement of leaf production of breadfruit root cuttings compared to cuttings treated with hormones. This finding implies that propagation of breadfruit for food production is readily manageable.

References

Barbeau G. 1992. Propagation Techniques. First regional workshop on tropical fruit crops: Passion fruit, avocado, citrus. Roseau Dominica 57-69.

Cadiz R, Cadiz NM, Nuevo CC. 2013. Clonal Nursery Establishment and Operation for the Production of Quality Planting Materials in Support of the National Greening Program. Training Manual. Ecosystems Research and Development Bureau. Department of Environment and Natural Resources. Laguna 27-33.

Dagatan MA. 2007. Effects of Various Concentrations of Rooting Hormones on the Rooting Performance of Different Nodal Segments of Spanish Cedar (*Cedrela odorata* L). (Masteral theses), Central Mindanao University, Philippines.

De Souza CT, Soares SAR, Queiroz AFS, dos Santos AMP, Ferreira SLC. 2016. Determination and evaluation of the mineral composition of breadfruit (Artocarpus altilis) using multivariate analysis technique. Microchemical Journal **128,** 84-88. http://dx.doi.org/10.1016/j.microc.2016.04.001

Englberger L, Lorennij R, Taylor M, Tuia VS, Aalbersberg W, Dolodolotawake U, Tibon L, Tibon J, Alfred J. 2014. Carotenoid content and traditional knowledge of breadfruit cultivars of the Republic of the Marshall Islands. Journal of Food Composition and Analysis **34,** 192-199.

FARC. 2012. Food and Agricultural Research Council (FARC). Mauritius Breadfruit Sector Consortium First Partnership Inception Workshop. http://docplayer.net/46800578-Mauritius-breadfruit-sector-consortium

Hartmann HT, Kester DE. 1975. Plant Propagation. Principles and Practices. Third Edition. Prentice-Hall Inc. Englewood Cliffs, New Jersey. USA.

Hocking PJ, Thomas MB. 1979. Effect of IBA in combination with thiram, captan, and benomyl on the rooting of four ornamental species. New Zealand J. Exp. Agric **7(3),** 263-269. http://www.tandfonline. com/loi/tnzc19.

Jones AP, Ragone D, Tavana NG, Bemotas DW, Murch SJ. 2011. Beyond the bounty: Breadfruit (*Artocarpus altilis*) for food security and novel foods in the 21st century. Ethnobotany Research and Applications **9,** 129-149.

Lomosbog NT. 2008. Leaf Production and Rooting Performance of Three Dipterocarp Stem Cuttings Treated with Varying Concentrations of Selected Rooting Hormones. (Masteral thesis), Central Mindanao University, Philippines.

Longman KA. 2002. Tropical Trees: Rooting Cuttings. A Practical Manual. Blaketon Hall Ltd. United Kingdom.

Lucas D, Ragone D. 2012. Will Breadfruit Solve the World Hunger Crisis? New Developments in an Innovative Food Crop. https://www.researchgate.net/publication/261871881_Will_breadfruit_solve_the_world_hunger_crisis_New_developments_in_an

Muller L. 1991. Archives of the Rare Fruit Council of Australia. New breadfruit trees from stem cuttings. Cardwell/Johnstone Brance Newsletter No **23,** Australia.

Needham A, Jha R, Lincoln NK. 2020. The response of breadfruit nutrition to local climate and soil: A review. Journal of Food Composition and Analysis **88,** 1-10.

Nickum MT. 2013. Food Security and Economic Sustainability: Current Research in Tropical Fruit Production at the University of Hawaii 1-7. http://www.ctahr.hawaii.edu/sustainag/news/articles/V15-Nickum-PhotoEssay.pdf.

Olatunya AM, Olatunya OS, Akintayo ET. 2017. Potential health and economic benefits of three locally grown nuts in Nigeria: implications for developing countries. Heliyon **3(10),** DOI: 10.1016/ j.heliyon.2017. e00414

Ragone D. 2018. Breadfruit-Artocarpus altilis (Parkinson) Fosberg. Exotic Fruits Reference Guide 53-60. DOI: http://dx.doi.org/10.1016/B978-0-12-803138-4.00009-5

Roberts-Nkrumah LB. 2015. Breadnut and Breadfruit Propagation: A manual for commercial propagation. Food and Agricultural Organization of the United Nations. http://www.fao.org/3/a-i3085e.pdf

Siddiqui MI, Hussain SA. 2007. Effect of Indole Butyric Acid and types of cuttings on root initiation of *Ficus hawaii*. Sarjad Journal of Agriculture **23(4),** 919-925.

Tamegnon AK, Innocent BY, Celestine TCK, Roseline B, Pivot SS, Anayce DA, Jultesse BSB, Paulin A. 2017. Uses of the fruit of Breadfruit tree (Artocarpus altilis) in the Republic of Benin: Bibliographic Synthesis **11(5),** 69-81.

Tare JZ. 2014. Rooting Performance of Molave (*Vitex parviflora* A. Juss) Cuttings Under Various Factors in Non-Mist Propagation. (Masteral thesis), Central Mindanao University, Philippines.

Turi CE, Liu Y, Ragone D, Murch SJ. 2015. Breadfruit (Artocarpus altilis and hybrids): A traditional crop with the potential to prevent hunger and mitigate diabetes in Oceania. Trends in Food Science & Technology **45,** 264-272.