PHILIPPINE COCONUT AUTHORITY RESEARCH JOURNAL (PCARJ)
ISSN NUMBER: 3028-1393

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This is published semi-annually by the Philippine Coconut Authority (PCA) with the address: PCA Building, Elliptical Road, Diliman, Quezon City

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First Published: June 15, 2024

ISSN Print: ***3028-1393***

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About the Journal

The Philippine Coconut Authority Research Journal (PCARJ) is a print journal which aims to provide valuable and fresh perspectives on the coconut and palm oil sectors, agriculture, and sustainable development. Initially, this journal was submitted to the National Library of the Philippines for the application of its International Standard Serial Number (ISSN) through ISSN Portal (https://portal.issn.org/). In collaboration with the PCA Research & Development Branch, the journal is submitted to local and international indexation bodies for a wider dissemination.

The Philippine Coconut Authority Research Journal (PCARJ) is a peer-reviewed print journal published twice a year which highlights the latest research and trends in coconut and palm Industries.

The journal welcomes full-length research articles, reviews, perspectives, and commentaries from researchers in the academic and industry sectors and/or research conducted by the PCA Research and Development Branch.

The PCA Research Journal aggressively promotes an inclusive and representative publishing culture while upholding stringent ethical publication requirements.

ISSN PRINT: 3028-1393

Editorial and Preface

The Philippine Coconut Authority Research Journal (PCARJ) is delighted to present its First Issue, Volume 1 No. 1, June 2024. This first local journal publication is dedicated to agricultural education, bioenergy, biotechnology, production, technology, management, environmental policy, health and wellness, manufacturing, food safety, food technology, and engineering, to name a few of the relevant fields of research.

It is a privilege to bring together professional researchers to create a platform that will inspire, invent, and revolutionize the coconut and palm oil sectors.

In a world that is rapidly changing, the importance of agricultural research cannot be overstated. It offers society a pillar of strength as well as a ray of hope for the future. This journal aims to serve as a bridge between research and practice, promoting collaboration and communication between the academe and the industry.

I thank the Editorial Board, reviewers, and the staff from the Office of the Administrator and the Research and Development Branch whose hard work and dedication made this first issue possible. I am also appreciative to our readers, whose engagement and support will ensure a smooth operation of our publication.

DR. DEXTER R. BUTED
Administrator/CEO
Editor-in-Chief

PHILIPPINE COCONUT AUTHORITY RESEARCH JOURNAL GUIDELINES

The ***Philippine Coconut Authority Research Journal (PCARJ)*** is a semi-annual publication produced by PCA under the leadership of its new administrator, ***Dr. Dexter R. Buted.*** With a focus on coconut and palm oil research, PCARJ stands as a refereed publication committed to presenting groundbreaking perspectives on agricultural advancements.
This journal is submitted to various online platforms which are indexed by Google Scholar and other indexation bodies.

AIMS AND SCOPE

The PCARJ is an interdependent journal that is subject to peer review. This local journal publication is dedicated to myriad of facets in agriculture such as: agricultural extension, production, technology, management, environment, policies, health and wellness, manufacturing, food safety, food technology, varietal improvement and biotechnology, food and non-food products, bioenergy, technology transfer, and engineering are just a few of the pertinent research fields that are included in the PCARJ.

The primary goal of this publication is to serve as a platform for disseminating high-quality and cutting-edge research, innovative methods, and stimulating discussions within agricultural domains. Further, it aims to encourage collaboration and knowledge exchange among coconut researchers, scientists, educators, practitioners, and policymakers as they address the complex issues and opportunities in these interwoven domains of agricultural education and industry.

PURPOSE

The PCARJ encourages the integration of various research from different authors and researchers in order to have a thorough knowledge of the agricultural landscape. The PCARJ's main goals are to increase understanding, promote collaboration, and provide significant input into the development of informed policies and practices in the ever-changing and dynamic fields of agricultural education and research.

TYPES OF RESEARCH ARTICLES PUBLISHED

Apart from the ***basic and applied research***, the PCARJ welcomes submissions that fit under the following areas:

1. **Research articles based on original investigations**

A primary terminal report is submitted to the **Research and Development Branch** and to those who are directly involved in carrying out the research investigation. Since the journal has just been created, the coconut researchers are required to submit their research paper using the IMRAD format. This contains five main sections that outline the researchers' study. It includes an abstract, list of credited sources, and tables/figures. The main components of its fundamental structure should be the five (5) main sections:

a) Introduction
b) Methods
c) Results
d) Discussion
e) Conclusions

The Introduction provides an overview of the pertinent literature, theoretical underpinnings, framework, and importance. The methodology includes the study's framework, individuals involved, tools utilized, processes followed, analysis of data, and maintenance of data. The Results section provides a comprehensive presentation of the collected data and findings, while also addressing the study questions. The Discussion section analyzes the findings in connection with the theoretical literature and framework. Ultimately, the Conclusions section presents the overarching findings and proposed suggestions.

An Original Research Report typically consists of approximately ***6,000-8,000 words***, excluding references, tables, and figures. The maximum allowable word count for the abstract is 250 words, accompanied by 5 keywords. Manuscripts must adhere to APA 7th edition guidelines for formatting, references, and citations.

2. **Theoretical Analyses**

A theoretical review is a systematic examination and integration of relevant literature about a fundamental subject within the agricultural domain. It offers a thorough overview and evaluative examination of scholarly literature, elucidating the current status of research or the specific subject of study. The theoretical review should provide insights for practical application and analyze the consequences for educational practice. It offers insights on the future direction of the field and the corresponding areas of research. The components of the theoretical review include:

The introduction defines the essential principles and scope of the review. The strategy describes the specific steps that are taken. The review section explains the systematic review results. The critique of the research literature looks at the underlying themes, omissions, and trends in the literature. The conclusions and suggestions section summarizes the findings and identifies topics for future research and program enhancement.

The Theoretical Analyses typically span approximately ***6,000-8,000 words***. Authors are strongly advised to include at least 10-20 primary research articles in the analysis of the theoretical review. The abstract should have a maximum of 250 words with 5 keywords. The document must be formatted, referenced, and cited using the APA 7th edition criteria.

3. **Case Analyses**

Case analyses necessarily involve a comprehensive examination and assessment of specific agricultural circumstances or problems. When crafting paragraphs for case analysis, it is essential to follow a meticulously organized approach to guarantee lucidity and logical flow.

The introduction clearly outlines the objectives of the work, the pertinent context, and the specific subject or concerns being addressed. This method delineates the criteria by which policy options can be assessed. The policy analysis component conducts in-depth research to support proposed policy actions, encompassing the evaluation, alteration, formulation, or termination of policies. The conclusions and recommendations section provides a succinct summary of the research findings and proposes specific actions to improve policy.

The Case Analyses typically consist of approximately ***6,000-8,000 words***. It is strongly advised to include at least 10-20 primary research articles in the analysis of the theoretical review. The abstract should have a maximum of 250 words with 5 keywords. The document must be formatted, referenced, and cited using the APA 7th edition criteria.

ETHICS STATEMENTS

The PCARJ is committed to maintaining the utmost integrity in research and publication by adhering to the highest ethical standards. Authors, reviewers, and editors are required to follow norms that promote honesty, openness, and responsibility in the scientific publishing process.

Authors must guarantee the originality of their manuscripts and affirm that they have not already been previously published elsewhere. It is vital to properly acknowledge all sources and contributions, and any potential conflicts of interest must be publicly disclosed. Plagiarism in any form is strictly prohibited, and authors are strongly advised to follow appropriate citation standards. The journal permits a maximum of 15% rate plagiarism as determined by a reliable plagiarism detection software.

The Editorial Board oversees the rigorous process from manuscript submission to publication. Editors ensure fairness and impartiality in their assessments, evaluating manuscripts based on excellence, relevance, and inimitability, regardless of authors' affiliations or backgrounds. Manuscripts are treated with strict confidentiality, and submission information is not disclosed without author’s consent.

Reviewers play an important role in ensuring the quality and integrity of the whole publishing process. They are expected to provide impartial and objective evaluations of the submissions. Reviewers are also expected to keep all manuscripts completely confidential and to publicly declare any potential conflicts of interest. They offer constructive criticism to help authors improve their work. Review findings are treated as strictly confidential documents by the Philippine Coconut Authority.

External reviewers may be invited from various kinds of public and private entities, as well as colleges and universities. They will contribute to the journal as needed, based on their area of expertise.

The editors are committed to maintaining objectivity and justice throughout the editorial process. The editorial assessments are based on the work's excellence, relevance, and uniqueness, without regard for the writers' affiliations or backgrounds. Editors will treat manuscripts with complete confidentiality and will not reveal any submission information without appropriate consent. The editor-in-chief has a close coordination with the consultants when there is a need to discuss important matters about the journal.

The PCARJ adheres completely to the principles and norms of responsible and ethical research. Authors must follow appropriate ethical principles and norms, such as obtaining informed consent for human subject's research and protecting individuals' rights and privacy. A Data Privacy Form must be completed and submitted by the author to the PCA Research and Development Branch (RDB).

Peer Review Policy

The PCARJ employs a rigorous peer-review process, consisting of three phases: compliance with submission prerequisites, initial screening, and comprehensive evaluation. Thus, it ensures the quality and integrity of published research. During the first issue, the Office of the Administrator (OFAD) in collaboration with the Research and Development Branch will facilitate the process of review.

PUBLICATION PROCESS

1. Submission:

Authors/Scientists submit their research manuscripts via google form or to this email: pcapublications@pca.gov.ph. Submissions are expected to adhere to the journal guidelines for manuscript preparation and submission. The submitted articles will be subjected to a rigorous review procedure. Authors are required to promptly communicate with the RDB or the ***managing editors*** under OFAD throughout the process.

2. Initial Review:

Upon submission, the editorial team conducts an initial review of the manuscript to ensure adherence to the journal's guidelines and to ensure the manuscript's alignment with the journal's scope and focus. Manuscripts that do not meet the journal's basic requirements may be returned to authors/scientists for ***revision at this stage***. Additionally, at this stage, the editors will assess the submission for compliance with the requirements of PCARJ, as well as for any resemblance to other works and instances of plagiarism through a software like Turnitin with a maximum of 15 % similarity index.

3. Review Process:

Manuscripts that pass the initial review are sent out for another review process. Expert reviewers with relevant expertise in the subject area of the manuscript will ***evaluate the manuscript for its quality, originality, methodology, significance, and contribution to the field.***

4. Reviewer Reports:

Reviewers provide detailed reports assessing the strengths and weaknesses of the manuscript. Based on these reports, submitted articles have the possibility of being accepted without revisions, accepted with minor revisions, revised manuscripts with major revisions, or not accepted at any of these stages.

5. Author Revisions, If Necessary:

Authors receive feedback from reviewers and the editorial team as stipulated in the Notice of Acceptance issued by the RDB. If revisions are required, authors are typically allowed to address the reviewers 'comments and make necessary changes to their manuscript.

6. Editorial Team Decision:

The Editorial Board will make the final decision regarding the acceptance or non-acceptance of the paper.

7. Proofreading and Copyediting:

Accepted manuscripts go through proofreading and copyediting to ensure language clarity, style consistency, and proper formatting.

8. Publication:
Once the manuscript is finalized and the author is satisfied with the proof, the article will be published in the Philippine Coconut Authority Research Journal (PCARJ).

9. Ethical Considerations:
The journal takes issues of research integrity and ethical conduct seriously. Plagiarism and research misconduct are rigorously monitored and violating authors will be reprimanded accordingly.

11. Author Recognition:
All researchers will receive **a Certificate of Publication to recognize their scholarly works signed by its Editor-in-Chief and/or PCA Administrator.** These certificates will be awarded during the Flag Raising Ceremony of PCA or in a formal forum like conferences or congress.

SUBMISSION GUIDELINES

Style Guidelines

1. The Philippine Coconut Authority Research Journal (PCARJ) accepts papers written in English.

2. Use bold Times New Roman font with ***a font size of 12 for the title***. Capitalize all proper nouns and omit the use of a period after the title.

3. The authors of the manuscript should have made significant contributions to the intellectual content of the work, including the conception, design, development, analysis, and critical writing. Upon submission of the manuscript, all authors are expected to take responsibility for their contributions and have given their consent to the final version of the manuscript and its submission to the PCARJ.

4. All headings must be formatted in ***Times New Roman with a font size of 12***. Apply capitalization to the initial letter of proper nouns. To differentiate between the various levels of headers, adhere to the following instructions:

5. The abstract, acknowledgments, and main body of the paper should be formatted using Times New Roman font, size 12, and double spacing.

6. ***The abstract*** should be placed on a distinct page and must not **exceed 250 words** with five (5) Keywords.

7. Adhere to the ***APA 7th edition*** requirements when it comes to referencing and citations, as well as the formatting of tables and figures. ***Use Times New Roman typeface with a font size of 12 for consistency.***

8. The manuscript should adhere to a consistent ***single-column layout*** across the entire document.

9. Tables and figures should be added according to APA 7th edition style guidelines. ***The titles in the table should be written on top*** while the **figure titles** should be written **below it**.

10. The ***acknowledgment section*** should be included.

11. The PCARJ adheres to the formatting requirements outlined in the 7th edition of the American Psychological Association (APA) Publication Manual. These guidelines include the structure and presentation of manuscripts, tables, figures, citations, and references in scientific and scholarly publications. For further details, visit https://apastyle.apa.org.

12. Other concerns, queries, or clarifications may be emailed to pcapublications@pca.gov.ph or da.rdb@pca.gov.ph.

ISSN PRINT: 3028-1393

OPEN CALL FOR PAPERS FOR PHILIPPINE COCONUT AUTHORITY RESEARCH JOURNAL

The primary objective of the PCARJ is to promote academic research on both theoretical and practical aspects of the agricultural sector. The PCARJ publishes articles that comprehensively document and examine the experience in the field of agriculture. It could be based on well-grounded theory, rigorous methodology, and/or perceptive analysis. Additionally, it serves as a platform for conducting comparative research in education and agriculture settings.

The PCARJ welcomes submissions of basic and applied research, original research reports, theoretical reviews, and policy studies as part of its scholarly journal.

Join us in our mission to promote excellence in agricultural research and contribute to the growth and development of the agricultural sector. Submit your manuscripts to the PCARJ and be part of our community of scholars dedicated to advancing agricultural science and practice.

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ACCELERATED DEVELOPMENT OF COCONUT SYNTHETIC VARIETY USING CLASSICAL BREEDING METHODS AND MICROSATELLITE MARKER TECHNOLOGY

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Philippine Coconut Authority

Abstract

With some modifications of the classical breeding method, a scheme was formulated to produce the base populations (Syn0) of the first synthetic coconut variety using single crosses from six outstanding tall cultivars. The possibility of generating an array of parental palms bearing balanced heterozygosity and stable yield is now being pursued through the application of classical breeding approaches and the advances in microsatellite marker technology. Using the equation of Eberhart et al (1967), eight double cross populations with the highest predicted copra and nut yields were identified and became the basis for the selection of ten t x t single crosses as parental materials in the production of seednuts for the establishment of 2nd generation breeding lines (Syn1). Coconut seedfarm establishment was completed following the field planting of 1,921 progeny seedlings. DNA analyses of the test materials provided promising results towards generating an array of parental palms bearing balanced heterozygosity with stable yield. Using four SSR markers, Syn1 have higher levels of heterozygosity compared to Syn0 and the parental populations. In some cases, levels of heterozygosity were sustained with greater evenness in allelic frequencies towards the advance generations. Genetic diversity of Syn1 was very high at 0.92.

Keywords *– Coconut synthetic variety; microsatellite marker (SSR); heterozygosity; genetic diversity; and controlled hand pollination.*

Introduction

The use of seeds from any high yielding planting materials is a traditional practice among coconut farmers. This practice although wise and practical sometimes leads to disastrous results when applied to seeds from F1 hybrids and worse if it involves taking them from dwarf x tall (d x t) single crosses. Unknown to many farmers, d x t hybrids inherit the self-pollinating trait of the dwarf parent. In a plantation of d x t palms, open pollination among these palms produces inbred seeds with higher frequency. This mating process leads to inbreeding depression, which is expressed in lower yields and general decline in the vigor of the succeeding generations.

Farmers who tried planting d x t hybrids during the last 20 years have mixed opinions about their choice of planting materials. In general, most Filipino farmers prefer high yielding planting materials with medium to large size nuts. They disregard small seeded ones because they had been used to the traditional commercial variety, which naturally bear medium to large nuts. Moreover, farm labor costs involved from nut harvesting to copra processing are paid on a per nut basis.

Many locally bred hybrids perform 3 to 4 times better than the traditional varieties due to their more efficient nutrient utilization. They are early bearing, "short" stature, and therefore, easy to harvest. Due to greater adaptability, they also have the desirable trait of superior recovery after a period of stress. They make up for lost yield in a short period of time; hence they have become the popular choice in agricultural development. Unfortunately, the use of hybrids requires big investment on seed production which cash-strapped governments like the Philippines can ill afford to sustain.

The development of open-pollinated varieties (OPVs) offers greater advantages because farmers can use the seeds of the original plantation over succeeding generations, again and again. The fundamental aim is to produce a population of palms having a high degree of balanced heterozygosity (Banzon and Velasco, 1982). This breeding scheme is considered by many coconut breeders impossible to do due to the perennial nature of coconut. Based on the breeding procedure for a synthetic variety, a modified breeding method was developed by PCA for coconut. Notwithstanding the limitations of possible inbreeding, and the difficulties of identifying the superior genotype (e.g. heterozygotes) during or after open-pollination, the development of synthetic varieties could be a more cost-effective means of plant propagation for coconut since it would ensure the deployment and use of superior planting materials with durable stability and yield. Using a 15-year data, Rivera et al (2008) presented a comprehensive report on the status and prospects of the development of coconut synthetic variety, in particular the development and performance of the t x t base populations (Syn0) compared to the parental populations, including the initial application of microsatellites or simple sequence repeats (SSRs) marker technology.

Advances in DNA technology show that SSR markers for coconut could discern between phenotypically similar varieties and/or plant types with heterozygous genotypes even at the nursery stage (Rivera et al., 1999). The application of this robust DNA technology is facilitating the current efforts on the development of OPVs, in particular the PCA-Syn Var 001 from 14 variety hybrids (Rivera et al., 2008).

Optimum utilization of molecular marker technology could make significant impact on the methods of assessment of the genetic structure of coconut populations as well as in locating desirable genes in breeding materials. With such applications, important phases in the conventional breeding protocol such as in case of development of coconut OPVs through the synthetic variety approach, and the identification of heterozygous individuals possessing desirable traits can be accelerated. Moreover, the identification and use of linked markers could facilitate the selection and higher probability of obtaining desired genotypes. These techniques, once properly developed and utilized, could pave the way for coconut breeders to optimize genetic improvement methods.

This research work aims not only provide information on the genetic structure of the resultant populations from the PCA SYN VAR foundation parents with that of the DNA patterns of the inter-crossed t x t F1 hybrids, but also more importantly apply the DNA molecular marker technology to complement the classical breeding methods in identifying and selecting superior materials at the earliest time possible, i.e. seedling stage, for the establishment of coconut seedfarms. The application of DNA marker technologies could accelerate the establishment of coconut seedfarms using PCA Synthetic Variety and provide the necessary genetic diversity in future coconut stands. Using the same technology, a protocol could be developed and utilized in the assessment and accreditation of coconut plantations for possible sources of high-quality planting materials for accelerated planting/replanting program.

METHODS AND PROCEDURE

Microsatellite loci were scored individually, and the different alleles were screened and recorded for each parent population and breeding lines. Two different inter-sample similarity matrices were constructed (1) based on shared alleles using the simple matching coefficient calculated at each locus separately, and then the mean across loci were taken; and (2) each allele was treated for every locus as a separate band, and the Jaccard coefficient was used as the measure of similarity analogous to the manner in which RAPD and AFLPs are scored. Cluster analysis was performed on the similarity matrix using the unweighted pair group method with arithmetic averages (UPGMA), and the resultant dendograms were constructed. The similarity matrices were put into a principal coordinate analysis (PCO), and the scores for the resultant first three components were plotted pair-wise. Genetic diversity ($D = 1\text{-}\Sigma pi2$) values were calculated according to Nei (1973). Data on the number of polymorphic loci, allelic richness, % heterozygosity and the kind alleles present were recorded.

RESULTS AND DISCUSSION

Hybrid Seednut Production Using the Classical Breeding Methods

Pollen Collection and Processing

Coconut pollen utilized in the hybridization works amounted to 1,620 g for the AP and 718.5 g for the CHP techniques.

Coconut pollen collection and processing started on the early part of 2006 while the mother palms are being prepared for CHP and AP operations. For the AP activities, the coconut pollen were collected and processed in bulk. On the other hand, for the CHP operation the coconut pollen used were those from the targeted source palms, collected and processed individually from each palm.

Production of Seednuts and Seedlings from the Hand Pollination

From the harvested pollinated nuts, 14,394 and 2,047 nuts from AP and CHP techniques, respectively, were sown in nursery beds. AP and CHP activities commenced on August 2006 with AP operations ending on September 2007 while CHP activities were completed in June 2008. Harvesting of pollinated seednuts commenced one year after hand pollination. Out of the 9,680 germinated AP seednuts, 4,086 were selected for polybag nursery operations while 1,534 seedlings were polybagged from 1,728 CHP nuts. The produced pollinated seednuts are more than enough to cover the establishment of one coconut seed farm consisting of 2nd generation (Syn$_1$) of breeding lines of the Syn Var population at the PCA-Zamboanga Research Center.

The rest of the pollinated seednuts were utilized for the establishment of coconut seedfarms in the PCA Research and Regional Centers and identified farm sites in strategic coconut growing provinces of the country. The results of such activities are covered by another report.

Coconut Seedfarm Establishment at PCA-ZRC

A total area of 20 hectares was cleared in the northern side of the original Syn Var area near the Sax River inside the PCA-ZRC for the establishment of coconut seedfarm. Field planting was done from October 2008 to March 2009 consisting of 1,921 progeny seedlings produced from CHP (702 seedlings) and AP (1,219 seedlings) covering an effective area of 12 hectares.

The vegetative data of the field planted seedlings i.e. girth size, plant height and number of leaves produced, of the Syn$_1$ breeding populations are likewise gathered and recorded which form part of another report. Standard cultural management procedures for coconut plantation are followed. Rubber trees are planted around the perimeter of the seedfarm to serve as natural barriers.

Application of SSR Marker Technology

Four coconut SSR primers, CNZ 18, CNZ 21, CNZ 51 and CN2A4 (figure 3) were utilized in the assessment of allelic diversity and/or molecular profiles, and levels of heterozygosity of the three generations of breeding populations. Results (table 4 and figures 4 and 5) point toward the genetic improvement of the advance breeding populations as indicated by reduced levels of homozygosity, higher percentages of heterozygosity, as well as high and sustained levels of genetic diversity.

Genetic diversity values of the breeding populations are very high (0.92) when all the four microsatellite markers are employed. Comparable levels of genetic diversity were likewise obtained when DNA markers are utilized singly. These levels were sustained in the advance breeding stages basically due the diverse tall coconut populations used as parent materials and the efficient breeding schemes employed.

DNA markers CNZ 51 and CNZ 18 detected six and three alleles, respectively. All alleles detected are in heterozygous state from the parents up to the advance breeding lines. In both makers, the evenness in the distribution of alleles is more pronounced in the advance breeding generations. Similarly, DNA markers CNZ 21 and CN2A4 found 3 and

4 alleles, respectively. Unlike markers CNZ 51 and CNZ 18, the detected alleles this time are in homozygous and heterozygous states. At the parental stage, levels of homozygote alleles are higher (with 85% for marker CNZ 21 and 83% for marker CN2A4) than the advanced breeding lines (Syn_0 and Syn_1). Homozygosity levels went down from 85% (parentals) to 45% (Syn_0), then to 40% (Syn_1) for marker CNZ 21. Conversely, their heterozygosity levels increased from 15% (parentals) to 60% (Syn_1). For DNA marker CN2A4, there was an abrupt decrease of homozygosity level from 83% to 5% from parents to Syn_0 then homozygote alleles level-off to 19% at Syn_1. At this breeding generation, heterozygosity level is 81%. Allelic richness is very visible while allelic evenness is more evident in the advance breeding stages.

The genetic improvement of the advance breeding populations is quite impressive as shown by the similarity matrices of the parentals, and the advance breeding lines (figure 6). The Jaccard Distance and PCA Matrices indicated more groupings in the advance breeding generations compared to the parentals indicating greater diversity or genetic variation in the breeding lines developed.

Allelic diversity analysis and molecular profiling require a certain minimum number of markers. The ideal number of markers for analysis should be at least two for each chromosome of the crop being studied, i.e. at least 32 markers for coconut (n = 16). The number of test materials should also be increased to an optimum level for higher confidence level in the results (Carcallas, 2001).

The abovementioned concerns could still be well addressed by the researchers since more polymorphic and discriminant SSR markers are available for use at the PCA-ZRC Molecular Genetics Laboratory. Likewise, the test palms of the parental and advance breeding lines are available as living collections, hence could easily be sampled for broader molecular profiling and genotype analyses.

The current results generated from the four SSR markers however, provided clear and positive indications that a population of palms with a high degree of balanced heterozygosity as suggested by Banzon and Velasco (1982) could be achieved. Moreover, development of a breeding scheme that would allow these populations to mate at random and to maintain high degree of heterozygosity and heterosis from generation to generation is possible. This breeding scheme is considered by many coconut breeders impossible to do due to the perennial nature of coconut. The PCA developed synthetic variety breeding scheme is a very cost-effective means of plant propagation for coconut since it would ensure the deployment and use of superior planting materials with durable stability and yield based on the yield performance of Syn_0 (Rivera et al 2008), and the indicative heterozygosity and genetic diversity of the Syn_1 breeding lines as shown by the current data from the application SSR marker technology.
The use of SSR markers in evaluating the breeding value of the genetic materials at seedling stage augurs well in the current efforts to accelerate the development of the PCA Synthetic Variety. While the development of the coconut synthetic variety was originally conceived to be totally dependent on the coconut breeder's unique instinct on individual

palm selection, the SSR marker technology could very well facilitate the efficient genetic assessment of the breeder's breeding populations. This robust technology complements well with the classical breeding methods being used in coconut varietal development program of PCA.

CONCLUSION & RECOMMENDATION

To accelerate the development of the PCA Synthetic Variety using the classical breeding methods, SSR marker technology was applied in assessing the allelic diversity, genetic/molecular profile, and levels of heterozygosity of breeding lines in relation to their parental populations. In particular, the SSR marker technology was applied in the genetic assessment of the 2nd generation (Syn1) breeding lines of PCA Syn Var produced using classical breeding methods from high yielding t x t F1 base populations (Syn0). The bottom line is to establish a coconut seedfarm comprising of 2nd generation (Syn1) superior breeding lines of PCA Synthetic Variety coconut variety.

Using the classical breeding methods, the 2nd generation (Syn1) of breeding lines of the PCA coconut synthetic variety from superior/high yielding lines of t x t F1 base populations (Syn0) was bred and/or developed. These breeding materials were genetically assessed using four SSR markers and were found to possess superior genetic values based on their levels of heterozygosity, genetic diversity, allelic richness, evenness of allelic distribution, and sustained genetic diversity. A coconut seedfarm consisting of 1,921 double crosses produced from both controlled hand pollination (702 seedlings) and assisted pollination (1,219 seedlings) covering an effective area of 12 hectares was established at the PCA-Zamboanga Research Center. This coconut seedfarm is expected to produce high quality seednuts of breeding populations that could be instrumental in the establishment of coconut seedfarms in strategic coconut growing provinces of the country.

While the Syn Var project was originally conceived to be totally dependent on the coconut breeder's unique instinct for individual palm selection, the application of the application of DNA molecular marker technology like SSR provides for fast and efficient assessment of breeder's breeding populations as well as generates information on the level of genetic diversity of existing stands of coconut in farmer's fields. When this robust technology is fully operationalized, the breeders will have the opportunity to quickly frame up an effective way of mass-producing the seeds for eventual multiplication of the relevant genotypes for coconut growing communities. This unique breeding research undertaking for coconut offers greater opportunities for all farmers not only in the Philippines but to all coconut growing countries in the world.

The purposeful development of a coconut synthetic variety could lead to more permanent genetic gains over many generations and could achieve greater adaptability and stability in performance due to a wide genetic base. Likewise, seeds of the coconut synthetic variety are produced under natural conditions and constantly exposed to natural selection. Coconut farmers may use the seeds from synthetic variety directly from a second crop and expect better yields in the process. Over the years, establishment of coconut seedfarms could sustain immense commercial hectarage over time and even in places where areas are too small to support a coconut hybrid industry.

The abovementioned advantages of the synthetic variety approach in coconut breeding are masked by the fact that a coconut synthetic variety is very difficult breed and even considered impossible by some coconut breeders due to its perennial nature. The research efforts done so far by the PCA breeders in Zamboanga have proven that a COCONUT SYNTHETIC VARIETY could be achieved through the combination of classical breeding methods and the application of robust molecular marker technology.

To take advantage of this "first of its kind in the world" coconut synthetic variety, the following are recommended:

1. To develop a robust and working DNA molecular marker protocols, like SSR or combinations of available DNA molecular markers for coconut, for genetic assessment to fully complement the classical breeding methods in the development of the synthetic breeding populations, and to further accelerate the coconut varietal development in the country;
2. To use the current breeding materials developed from the synthetic variety approach in the establishment of productive coconut seedfarms in strategic coconut growing provinces of the country; and
3. To further assess the potential of the coconut synthetic variety for emerging and high value products and uses.

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APPLICATION OF COCONUT EMBRYO CULTURE TECHNIQUE ON FIELD COLLECTION AND *Ex situ* CONSERVATION OF THE TUTUPAEN TALL VARIETY (TPNT)

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Abstract

For the first time in the Philippines, the embryo culture technique (EC) was used to collect a coconut variety from the field for ex situ conservation. The EC technique proved to be an important tool for collecting and moving germplasm safely and conveniently. This is especially so in the case of coconut because of the large size of the seednut, the lack of dormancy, and the fact that pest and pathogens can be transported with the seednuts. The field collection of Tutupaen Tall embryos done in Sarangani province demonstrated the robustness of the embryo culture technique, and facilitated the collection of a new and very distinct coconut accession for ex situ conservation. The Tutupaen Tall is an important variety distinguished by its very unique thick shell (0.75 cm or more). This variety became the 263rd accession in the coconut field gene bank of PCA in Zamboanga. A total of 411 seednuts were harvested from which 262 true-to-type Tutupaen Tall endosperm plugs were collected, and transported to PCA-ZRC. The effectiveness of the protocols used on collecting, transport, and culture of the embryos for coconut genetic conservation is presented.

Keywords *– Embryo culture technique; Tutupaen Tall variety; coconut genetic resources; ex situ conservation.*

Introduction

Coconut, Cocos nucifera L., is a good example of an important crop that provides social and economic development in more than 85 countries in the world. Its global scope as well as major concerns like genetic erosion, and the fact that genetic resources are not renewable, provide greater emphasis on the importance of coconut conservation and evaluation. But due to its recalcitrant nature, coconut is difficult to conserve as seeds. Hence, coconuts are generally conserved in field gene banks (FGBs) where accessions are conserved as living collections. This system of conservation provides continuous opportunity for evaluation as well as an easy and ready access of the conserved germplasm for research and use.

At present, the coconut gene bank of the Philippine Coconut Authority in Zamboanga remains as an active breeding and genetic reserve and recognized as one of the most important collections in the world with emphasis on indigenous accessions. From 41 accessions in the 1980, its coconut collection has reached 262 accessions. Efforts to increase these figures is important considering the enormous genetic variability that is still present in the coconut growing areas since only 60% of the country has been explored since 1970s. However, collecting coconuts over a wide geographic area for ex-situ conservation is a tremendous task. And the establishment and management of coconut gene bank require a remarkable number of resources due to its perennial nature. Hence, tools and techniques that can contribute to a more effective collecting and propagation of coconuts should be utilized. This study presents the application of coconut embryo culture technique on field collection, and ex situ conservation of the Tutupaen tall variety (TPNT).

METHODS AND PROCEDURE

Sampling and Location

The Tutupaen Tall variety (TPNT) was chosen for the collecting mission due to its unique thick shell and its contribution as a new accession in the germplasm collection at PCA-ZRC. The TPNT was collected from Sarangani Province and some areas in General Santos City in Region XII, Mindanao Island. The number of samples collected was estimated for a hectare of field establishment.

Protocol 1: The PCA-ZRC Embryo Culture (EC) Protocol

Field collecting of embryos

The collection protocol used followed the IPGRI-COGENT Stantech Manual (Santos et al 1996) with the inclusion of the PCA's EC technique (Rillo 1995).

During field collection, 10-11 months old nuts (color break stage) were harvested. At this age, the embryos are on the right stage for collection. The harvesting tool used is made of a fabricated scythe (curved sharp knife with long stem) attached to the end of a special bamboo pole "Lampaki" variety.

Harvested nuts are hauled to the designated de-husking areas. The husk was removed off the nut (de-husking) using a pointed but blunt metal, normally the tip of a farmer's plow share mounted on a sturdy wooden base. The nut was split open using the blunt side of a bolo and by striking the prominent longitudinal vein crosswise with sufficient force. A cylinder of endosperm embedding the embryo is extracted using a large size cork borer with 2 cm diameter. Endosperm plugs were rinsed with tap water, and in 95% ethanol to quickly remove the fats, sterilized with 100% commercial bleach for 20 minutes, and washed three (3) times with distilled water. The cylinders were then kept in sterile bags with moistened cotton, and placed inside the Styrofoam box in between layers of papers. Ice bags were added to keep the cylinders cold. The box was covered with packing tapes before transport.

Transporting of Collected Embryos

The sealed Styrofoam box containing the collected embryos was transported by air as checked-in baggage of the collector. Upon arrival at the laboratory, the coconut embryo culture laboratory procedure was followed.

Germination of Embryos In Vitro

In the laboratory, the cylinders were washed three times with sterile tap water. The cylinders were then transferred to the laminar flow cabinet for excision and subsequent culturing of embryos. From here on, aseptic procedures are strictly followed to avoid contamination. Under aseptic conditions and using scalpels and forceps, the embryos were excised from the solid endosperms. Scalpels and forceps are regularly sterilized by dipping in 95% ethanol and flaming them after each excision. After all the embryos have been excised, they are again disinfected with 10% commercial bleach for 1-2 minutes and rinsed five (5) times in sterile distilled water. Commercially available distilled drinking water is used for media, and for all preparations at ZRC in the absence of distilling apparatus. Embryos were transferred singly into "catsup" bottles containing Y3 liquid medium, and cultured at 27-30^{o}C with approximately 4,000-5,000 lux at 9-hour photoperiod. Shoots and roots normally emerge after two weeks. Culling was done on poorly developed embryos 16 weeks or four months after inoculation. Abnormal or slow growing embryos and plantlets are likewise discarded.

Growth of Plantlets In Vitro

Using the same Y3 liquid medium but with only 45g of sugar, the diluted freshly prepared culture medium was added after decanting the old medium. The same media preparation was used to replace the succeeding culture medium. Plantlets remained in the laboratory for three to four months. At this age the plantlets have well-developed shoots, and enough secondary and tertiary roots. The culture vessels are transferred to screen house for the optional hardening stage followed by acclimatization of seedlings.

Culture in Screen House/Nursery

The well-developed plantlets were taken out by breaking the culture bottles. The seedlings were washed under tap and dipped in strong fungicide (e.g. Captan, Vitigran Blue) solution before they were planted in sterile clay pots containing sterile coco peat and fine river sand at 1:1 ratio. High humidity level is maintained during the first three weeks by covering the potted seedlings with plastic bags supported by sturdy steel wires. The seedlings were placed under the three-layered nylon net upper covering inside the screen house. Watering was done through a small hole at the side of the plastic bag near the mouth of the pot and then closed after watering. Every other day, the plastic cover is lifted up a few inches to gradually expose and acclimatize the seedlings to the screen house condition. Fertilizer of 80 grams 14-14-14 diluted to 16 liters water was applied once a week. The seedlings remained in the clay pots for two months.

Growth of Plantlets

The plants were transferred to polyethylene bags measuring 14" x 14" filled with equal parts of non-sterile soil and sawdust. Seedlings were exposed under the one- layer nylon net inside the screen house. Watering was done as needed using water hose. Fertilization was done once a week by applying 120 grams of 14-14-14 fertilizer diluted to 16 liters of water. After one month, the plants are exposed to full sunlight and are ready for field planting.

Protocol 2: PCA-ARC EC Protocol

Compared to the Protocol 1, the PCA-ARC protocol (Protocol 2) uses powder detergent in washing the embryo plugs followed by rinsing in tap water. Soft parts of the endosperm plugs are removed. Then, still under non-aseptic conditions (outside the hood), the embryos are excised using a knife and collected in a beaker with water. Injured and soft embryos are discarded. The good quality embryos (whole and firm) are washed again with detergent and rinsed with tap water. The clean and selected embryos are then brought inside the laminar flow for final disinfection.

RESULTS AND DISCUSSION

The Collecting Missions

Two collecting missions at Sarangani Province, and some areas in General Santos City in Region XII, Mindanao Island were conducted from November 3 to 7, 2008 (1st Batch), and December 5 to 8, 2008 (2nd Batch). The target coconut variety during these collecting missions is the Tutupaen tall. The first collecting mission was conducted by 1 technical staff and 1 field staff of the Breeding and Genetics Division of PCA-ZRC. The second collecting activity was spearheaded by a technical officer of PCA-Albay Research Center (PCA-ARC) with technical support from one PCA-ZRC technical staff. Both collecting missions were in close coordination with the PCA Regional and Provincial Coconut Managers in the area to ensure harmonized assistance from their Regional/Provincial staff on administrative and related matters. The Chairman of the coconut farmers' Cooperative in Maitum, Sarangani Province provided assistance in identifying the farmers possessing the target variety, and in locating the palms in the field. The Tutupaen tall (TPNT) embryos were sourced from 13 and 14 coconut farms during the 1st and 2nd collecting missions, respectively.

The Collected Coconut Variety

Tutupaen is so-called after a game "tupa" (meaning, to hit, smash or strike), which is a very popular game among Ilocanos in the province of Pangasinan, and in the other northern provinces of the Luzon Island, Northern part of the Philippines. Apparently, when a group of Ilocanos migrated to the Mindanao Island in the Southern part of the Philippines some brought with them the planting materials of the Tutupaen variety, and planted them near their houses or in their farms.

The "tupa" game[1] is played in such a way that husked nuts (without water) of a pair of players are matched. Once there is a match, the player rolls down his nut on the court, usually a clean part of the yard or beach, and while the nut is rolling the other player strikes it with his own nut. This is done alternately until one of the nuts breaks. Whichever nut stays unbroken, the owner of the nut is proclaimed the winner by a selected judge.

A Tutupaen palm looks like the typical coconut. It is a late bearing tall, cross-pollinated and the stem is either with bole or slightly tapering at the base. The petioles and the young nuts are either lettuce green or orange of various intensities. Mature nuts vary in size (small, big, ordinary) and shape (round and oblong). Being planted solitary and used in the game, Tutupaen palms are logically named after their owners. Depending on their performance, the best palms are noted and nuts are therefore priced higher. A Tutupaen nut with its unique thick shell can only be confirmed by opening the nut to see the unique thick shell, i.e. 0.75 cm or more.

The characterization data gathered from the Tutupaen tall coconut variety sourced palms are as follows:

A.	Stem Morphology		
	1.	Girth at 20 cm =	163.7 ± 24.6
	2.	Girth at 1.5 m =	102.0 ± 7.4
	3.	Length of 11 leaf scars =	91.5 ± 19.1
	4.	Palm height =	908.3 ± 164.8
	5.	Bole category =	Low
B.	Overall Crown Appearance =		Spherical
C.	Leaf Morphology		
	1.	Color of petiole =	Green
	2.	Petiole length =	126.5 ± 9.3
	3.	Petiole thickness =	3.5 ± 0.4
	4.	Petiole width =	7.9 ± 0.4
	5.	Rachis length =	374.4 ± 29.8
	6.	Number of leaflets =	116.2 ± 6.8

7.	Leaf length (Mean) =	129.2 ± 12.2
8.	Leaflet width (Mean) =	5.6 ± 0.5

D. Inflorescence and Flower Morphology

1.	Type =	Normal
2.	Peduncle length =	33.7 ± 2.0
3.	Peduncle diameter =	2.9 ± 0.5
4.	No. of spikelets w/ female flower =	16.2 ± 6.3
5.	No. of spikelets w/o female flower =	19.2 ± 5.9
6.	No. of female flower =	17.8 ± 5.9
7.	Female flower distribution =	1.1 ± 0.3
8.	Length of central axis =	40.4 ± 3.9
9.	Length of spikelets =	46.8 ± 4.9
10.	Presence of receptive flower =	1.0
	Presence of male flower =	1.0

E. Fruit Appearance

1.	Fruit set =	20-50
2.	Fruit color =	Green
3.	Fruit shape (Polar) =	Ovoid/round
4.	Fruit shape (Equatorial) =	Angled/round
5.	Husked nut shape =	Ovoid/round
6.	Fruit length =	27.5 ± 3.0
7.	Fruit width =	19.6 ± 2.7
8.	Nut length =	15.0 ± 1.2
9.	Nut width =	13.7 ± 1.2

The Tutupaen Tall (TPNT) is now the 263rd accession at the PCA gene bank in Zamboanga, the latest tall coconut variety collection. This coconut accession has a great potential for the extraction of another high value product from coconut shell called xylose. Xylose, also called wood sugar, is a sugar first isolated from wood. It is a white crystalline sugar, $C_5H_{10}O_5$, used in dyeing and tanning, and in diabetic diets. An important product of xylose is xylitol, which is produced by hydrogenation, wherein the sugar (an aldehyde) is converted into a primary alcohol. One teaspoon (5 g) of xylitol contains 9.6 calories, as compared to one teaspoon of sugar, which has 15 calories. Xylitol has virtually no aftertaste, and is advertised as "safe for diabetics and individuals with hyperglycemia. This tolerance is attributed to the lower impact of xylitol on a person's blood sugar, compared to that of regular sugars. It also has a very low glycemic index of 13 (glucose has a GI of 100) (Gare 2003).

Status of the Coconut Embryos Collected and Cultured *In Vitro*

The November 2008 collecting mission utilized Protocol 1 (the PCA-ZRC protocol) in the collecting and processing of the Tutupaen tall embryos. A total of 225 Tutupaen seednuts was harvested. However, only 131 endosperm plugs were collected since the rest of the nuts were rejected for various reasons. A large number of nuts have already germinated; majority are either over matured, with sprouts, or spoiled. From the 131 endosperm plugs, 125 embryos were excised and sown.

Meanwhile, for the collecting mission conducted in December 2008 using Protocol 2 (the PCA-ARC collecting and processing protocol), a similar number of 131 Tutupaen tall coconut endosperm plugs were collected from 186 harvested nuts. Like in the 1st collecting mission, around 30% of the harvested nuts are already spoiled and/or have germinated. Only 108 embryos were excised and sown from the 131 endosperm plugs brought to the PCA Embryo Culture Makapuno Laboratory in Zamboanga. Most of the extracted embryo plugs have no embryos.

Tutupaen embryos from the 1st Batch have attained 75% germination, 11% did not germinate, and 14% were contaminated. The 75% germination is within the germination rates *in vitro* from ca. 60 to 85% with an expected further loss of 10% during the steps leading up to successful acclimatization of the seedlings (Adkins 2008). Meanwhile, embryos from the 2nd Batch reached only 50% germination rate. Cases of contaminated embryos were quite high at 37%. Meanwhile, 13% of the embryos did not germinate. The Protocol 1 utilized in collecting and culturing of embryos seems to work better than the Protocol 2 as shown by the level of contamination (14% vs. 37%). The cases of contamination during the early stages of culturing (i.e. first two months in culture) may have contributed to the low germination of embryos from the 2nd Batch of collecting mission. The described Protocol 2 EC process (excision of embryos under non-aseptic condition) may have increased the possibility of contamination and consequently, affected the germination of embryos. However, since such procedure works well at the PCA EC Makapuno Laboratory in Albay, other factors need to be considered and given another look. The response of the variety to *in vitro* culture may also be a determining factor in its performance considering that the germination rate ranges between 50-75% only or an average of 64%. This is below the 80% and above germination rate of other coconut varieties cultured *in vitro* including coconut embryos from Makapuno palms.

Status of *In Vitro* Coconut Plantlets

The Tutupaen coconut embryos sown, and maintained *in vitro* culture for the two collecting missions amounted to 233. This figure exceeded the minimum target of 180 embryos per coconut accession. From the 233 embryos, 148 plantlets (more than the minimum target of 135 plantlets) were raised in the laboratory consisting of 94 and 54 plantlets from the 1st and 2nd batches of collecting missions, respectively.

From these 148 plantlets, however, only 106 seedlings were transferred to the acclimatization chamber or screen house due high mortality rate in the 2nd Batch of collection (30 out of 54 plantlets or 56%). The mortality of plantlets in the 1st batch was only 13%, i.e. 12 out of 94 plantlets. As such, only 24 seedlings were produced in the 2nd batch of collecting mission compared to 82 seedlings from the 1st batch.

Status of Coconut Seedlings

From the 148 plantlets raised in the laboratory and 106 seedlings transferred to the screen house, only 90 seedlings were produced consisting of 78 seedlings in polybags and 12 seedlings in clay pots. This figure, however, met the target of 90 seedlings for field establishment. The relatively higher number of rainy days coupled with the increased volume of rainfall during the growing periods of the seedlings greatly contributed to the high mortality rate. Greatly affected are the plantlets from the 2nd batch of collecting activity (56% mortality). The decision to delay the transfer of the plantlets from laboratory to the screen house helped in reducing the mortality of seedlings to the 13% level, in particular those coming from the 1st batch of collecting mission.

Using Protocol 1, the 54% success rate in the 1st batch of collecting mission reckoning from the 125 Tutupaen coconut embryos sown wherein 68 seedlings are produced could be considered a very great achievement. To fully appreciate such achievement, when based on the 94 plantlets raised, the success rate was registered at 72%. This is within the upper limit of the 50-85% success rates recorded in routine collecting activities using coconut seednuts instead of embryos.

The relatively high contamination rates could be attributed to the inherent early germinating trait of the Tutupaen tall variety as well as the expected non-uniformity in the age of the harvested nuts which had affected the physical conditions of the embryos. These factors could easily be addressed in future collecting explorations.

In contrast, the 2nd Batch collecting mission achieved only 20% success rate or only 22 seedlings out of the 108 Tutupaen tall coconut embryos sown. Such performance is considered below the desired target, achieving only 41% success rate, reckoning on the 22 seedlings produced out of the 54 plantlets raised in the laboratory.

Status of Field Establishment of Coconut Seedlings

The area for the field establishment of the Tutupaen seedlings has been identified, and clearing operations are ongoing. Perimeter fence is also being established using 4-5 layers of barbed wires to protect the seedlings and discourage the entry of stray animals. The field clearing operations have been suspended several times due to the inclement weather prevailing in the Zamboanga Peninsula. Great consideration is given to the vulnerability of the seedlings to very wet weather condition, if field planting is pursued. The 90 seedlings met the target for the field establishment of the Tutupaen tall coconut variety.

CONCLUSION & RECOMMENDATION

The Tutupaen Tall (TPNT) collected successfully became the 263rd accession in the PCA-ZRC coconut gene bank. This important and distinct coconut accession fills the gap for a coconut germplasm with inherent thick shell. Aside from its great potential for the activated carbon product, the coconut shell of this coconut accession has a great potential for the extraction of another high value product called xylose. A Korean Company is establishing a processing plant in Davao to produce xylose from coconut shell.

The TPNT embryo collecting activities demonstrated the usefulness of the embryo culture technique in collecting, and in the safe movement of coconut germplasm.

Protocol 1, the PCA-ZRC EC protocol, utilized in collecting and culturing of embryos worked better than Protocol 2, the PCA-ARC protocol, as shown by the lower contamination rate; lower mortality rates from embryo to plantlets, and to seedlings stages; and higher success rate in producing coconut seedlings.

In general, the EC technique effectively produced 90 seedlings which met the required number of seedlings for field establishment.

The experiences and data generated from the collecting missions for TPNT using coconut embryos provided very concrete and good benchmark information as inputs during the workshop of Coconut Gene Bank Managers and Tissue Culture experts from coconut growing countries. The generated data and information reinforced several Workshop recommendations particularly on the international recommended standard protocol for *in vitro* culture of coconut embryos, to wit:

Collecting

Age of nuts	10-11 months
Extraction/disinfection	Commercial bleach 100% concentration, Albumen plugs : 20 min; Commercial bleach 10% concentration, Naked embryos : 5 min

Germination

Medium	Y3 (1976)/or modified Liquid/solid
Vessel	Test tubes bottles
Culture conditions	26-28°C ; Dark/light
Subcultures	2-3 /1-1.5 months

Acclimatization

Hardening in vitro plantlets	1 week in greenhouse or laboratory
Fungicide treatment	Yes Benlate Carbendazin
Substrate	Coir dust, soil and sand
Recipients	Pots, small polybags
Environmental conditions	Shade, 3-4 months
Fertilization	Yes
Watering	Yes
Duration	5-9 months
Transfer to larger polybags	Yes

The protocol is applicable to tall and dwarf coconut varieties, without any visible genotypic effect based on available data. The average success rate of the protocol is 34%; i.e. from 100 embryos inoculated in vitro, an average of 34 seedlings can be transferred to the field. The Workshop further recommended that this percentage be used as a benchmark for the application of the protocol. One accession of a Tall variety should be represented in the field by a minimum number of 90 palms. A minimum of 300 embryos of any tall coconut variety should thus be inoculated *in vitro* to obtain this minimum number of palms in the field.

The EC technique can be an effective, safe ,and convenient tool for collecting and moving coconut germplasm. A fully developed and working EC protocol could provide tremendous impact for coconut collecting explorations in remote places, and isolated islands, and more importantly, in the safe international exchange of important coconut germplasm. The EC protocol was demonstrated as important tool and very good option to the usual method of collecting the "bulky" coconut seednuts for conservation purposes.

The experiences and data gathered during the embryo collecting missions provided vital inputs during the workshop such that excellent recommendations on the EC protocol were established. Hence, as an offshoot of this study, Bioversity International through the International Coconut Genetic Resources Network (COGENT) is currently employing embryo culture protocol for an international exchange of coconut germplasm for safety duplication amongst four coconut growing countries namely, Cote d' Ivoire, Papua New Guinea, Sri Lanka and the Philippines. Initial collecting missions were done in February and July 2010 by PCA-ZRC technical officer getting two dwarf and two tall coconut accessions from Ivory Coast. The tall coconut accessions possess drought tolerant traits.

The EC technique used in the study ushered in a new era of a more efficient and safe international exchange of coconut germplasm. Other crops could explore and exploit the use of this EC technique for collecting and germplasm exchange programs.

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ACKNOWLEDGMENTS

The authors wish to express their gratitude to Bioversity International (Bioversity) for funding the research, Philippine Coconut Authority (PCA) Management (OFAD, RDB, PCA-ZRC) for the administrative and technical support, PCA Regional Office (Region 12), PCA Provincial Office of Sarangani and, Fleischer Estate Integrated Multipurpose Cooperative (FEIMCO) for the great help during the collecting activity.

THE COCONUT FARMERS AND INDUSTRY DEVELOPMENT PLAN (CFIDP) PROGRAM MILESTONES (2022 – 2023): AN IMPACT ANALYSIS

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Abstract

The Coconut Farmers and Industry Development Plan (CFIDP) is a crucial program designed to rejuvenate the coconut industry. However, there is a lack of empirical evaluations of its progress since the program implementation started only in 2022. This research study employed a quantitative approach to examine the various effects of CFIDP program milestones on coconut growers and the wider industry context. Utilizing a rigorous technique that encompasses the gathering of survey data and subsequent statistical analysis, this study examined the socioeconomic aspects, improvements in agricultural productivity, and market dynamics that are impacted by interventions implemented by the CFIDP. By employing a stratified sample method in important coconut-growing areas, the study encompassed a wide range of viewpoints and guarantees a thorough understanding of the program's effectiveness. This research provided significant insights for policymakers, industry stakeholders, and development practitioners who aim to promote sustainable growth and resilience in the coconut sector by examining the quantitative effects of CFIDP program milestones.

Keywords: *CFIDP, socioeconomic aspects, coconut farmers, industry development, livelihood.*

INTRODUCTION

Former ***President Rodrigo Roa Duterte*** signed **Republic Act No. 11524**, the Coconut Farmers and Industry Trust Fund (CFITF) Act, on February 26, 2021, that aims to consolidate benefits for impoverished coconut farmers, bolstering their income, lifting them from poverty, and promoting social equality. The Philippine Coconut Authority (PCA) is tasked to develop the Coconut Farmers and Industry Development Plan (CFIDP), aimed at steering the progress and revitalization of the coconut industry across a span of 50 years. This plan prioritizes enhancing productivity, reducing poverty, and promoting modernization within the sector.

The coconut business plays a vital role in the economies of numerous tropical regions globally, supporting the livelihoods of millions of people and making substantial contributions to national economies. In recent times, there has been a growing impetus in the adoption of focused development initiatives that seek to improve coconut farming techniques and promote sustainability within the business. An initiative that has gained significant attention from policymakers and stakeholders is the Coconut Farmers and sector Development Plan (CFIDP) Program. This program aims to tackle the difficulties encountered by coconut farmers and promote the expansion of the sector.

The CFIDP Programs, which were implemented from 2022 to 2023, aims to rejuvenate and update the coconut industry by achieving a set of strategic goals. The milestones in question involve a range of development factors, such as agricultural methods, enhancement of the value chain, access to markets, and socio-economic empowerment. The program seeks to optimize the effectiveness of interventions by clearly defining objectives and timetables. This will help streamline interventions, allocate resources efficiently, and evaluate progress effectively, ultimately optimizing their impact on the ground.

A thorough understanding of the ramifications associated with the milestones of the CFIDP Program holds significant importance for policymakers, researchers, and practitioners alike. Through the assessment of the results and consequences of these significant achievements, those with a vested interest can acquire vital knowledge regarding the efficacy of certain initiatives and pinpoint opportunities for additional enhancements. In addition, the evaluation of the program's effects promotes the use of empirical data in decision-making, allowing policymakers to enhance policies, allocate resources wisely, and customize interventions to effectively tackle growing difficulties and capitalize on opportunities in the coconut industry.

In light of this context, the objective of this research project is to investigate the effects of the CFIDP Program milestones that were put into effect between 2022 and 2023. The study seeks to evaluate the program's efficacy in attaining its stated goals and examine its impact on coconut farmers, industry stakeholders, and wider socio-economic progress through the utilization of a comprehensive research framework that incorporates both quantitative and qualitative methodologies. By employing empirical analysis and considering the viewpoints of stakeholders, this research aims to produce practical insights that can guide the creation of policies, program design, and strategic decision-making in relation to the growth of the coconut industry.

The CFIDP was developed through extensive consultation with fourteen other implementing agencies (IAs) as mandated by the law. It is designed in accordance with the primary objectives of the law, namely: (a) increased productivity and income of coconut farmers; (b) poverty alleviation, education, and social equity; and (c) rehabilitation and modernization of the coconut industry towards farm productivity. The CFIDP highlights six (6) National Development Programs which includes: (1) social protection, (2) coconut farmers' organization and development, (3) coconut hybridization program, (4) community-based enterprise development, (5) shared facilities program, and (6) support services.

Filipino Coconut Farmers

Coconut farming is a fundamental aspect of the agricultural industry in the Philippines, supporting the livelihoods of millions of farmers. Gaining insight into the socio-economic obstacles and prospects encountered by these farmers is essential for achieving sustainable development and formulating effective policies. Numerous scholarly investigations have explored diverse facets of coconut cultivation in the Philippines, encompassing its historical import as well as present-day concerns pertaining to productivity, sustainability, and socio-economic welfare.

Reyes and Garcia (2019) conducted a significant study that investigates the historical progression of coconut cultivation in the Philippines, encompassing its origins from the pre-colonial era to the contemporary period. This research offers significant contributions to the understanding of the cultural, economic, and environmental aspects of coconut production, hence illuminating its enduring importance within Filipino society.

The study conducted by Santos et al. (2020) provides a thorough examination of the various elements that impact the productivity and profitability of coconuts, with a particular focus on modern difficulties. The researchers employ a blend of quantitative surveys and qualitative interviews to uncover crucial factors, including land tenure regimes, credit accessibility, market dynamics, and technology advancements. The research highlights the intricate interaction between socio-economic variables that influence the economic prospects of coconut growers in the Philippines within the context of the contemporary globalized economy.

Furthermore, Lim et al. (2021) did a study that specifically examines the socio-economic consequences of climate change on coconut farming communities in the Philippines. The study utilizes a combination of qualitative and quantitative methodologies, such as household surveys and participatory workshops, to emphasize the susceptibility of smallholder farmers to severe weather occurrences, changing precipitation patterns, and the rise in sea levels. The results emphasize the pressing necessity for the implementation of adaptation methods and policy interventions aimed at bolstering the resilience of coconut producers in the Philippines when confronted with climate-related hazards.

Moreover, the scholarly investigation conducted by Cruz and Dela Cruz (2022) delves into the gender aspects of coconut cultivation in the Philippines, analyzing the involvement and impact of women in agricultural activities, decision-making processes, and value chains. From a feminist perspective, this study examines the imbalanced power dynamics, cultural conventions, and institutional obstacles that influence women's encounters in the coconut industry. The study supports the implementation of policies and programs that are sensitive to gender and aim to empower women farmers and advance gender equality in rural development projects.

To summarize, the literature on Filipino coconut producers cover a wide range of subjects, such as historical viewpoints, difficulties in productivity, adaptation to climate change, and gender dynamics. The studies presented in this collection together contribute to a comprehensive comprehension of the intricate aspects related to coconut farming in the Philippines. They provide essential perspectives for policy makers, researchers, and development practitioners who are dedicated to improving the welfare of coconut farming communities.

Coconut Farmers and Industry Development Plan

Academic literature has thoroughly analyzed the challenges and opportunities faced by coconut growers and the wider coconut industry. Smith (2018) conducted an in-depth analysis of the socio-economic obstacles encountered by coconut producers in developing nations. The study shed light on concerns such as diminished production, restricted market accessibility, and susceptibility to price volatility.

Furthermore, the study conducted by Jones and Patel (2020) delved into the influence of governmental policies on the developmental trajectory of the coconut industry. The authors underscored the significance of strategic planning and infrastructure investment in defining this trajectory.

In addition, Nguyen et al. (2019) performed a comparative examination of coconut farming methods in various locations, providing insights into the differences in agricultural techniques and their effects on crop productivity and environmental sustainability. This collection of papers highlights the complex and diverse range of issues faced by coconut producers, emphasizing the necessity of comprehensive development strategies that encompass both agricultural and socio-economic aspects.

The Influence of Coconut Farmers and the Strategies for Industry Development

The significance of the coconut sector in agricultural economies throughout many tropical regions has been well acknowledged (Birnbaum & Thomas, 2020). Various countries have tried government initiatives to improve the productivity and sustainability of coconut cultivation, with varying degrees of success (Jain & Reddy, 2019). The CFIDP program, which was initiated in 2022, signifies a noteworthy achievement in this context, as its primary goals revolve around enhancing the capabilities of coconut farmers and promoting the growth of the industry (Department of Agriculture, 2022).

Prior studies have emphasized the difficulties encountered by coconut farmers, which encompass issues such as diminished productivity and fluctuations in the market (Fernando et al., 2018). The Coconut Revitalization initiative in the Philippines, which shares similarities with the CFIDP initiative, has demonstrated encouraging outcomes in terms of enhancing crop productivity and generating income (Lana & Reyes, 2017). Nevertheless, the efficacy of these initiatives frequently relies on variables such as the allocation of resources, participation of stakeholders, and coherence of policies (Dahal & Khadka, 2021).

In addition, it is important to note that coconut farming has a broader socio-economic influence that goes beyond its agricultural productivity. This influence extends to other elements, including rural livelihoods and environmental sustainability (Chowdhury et al., 2020). According to Obisesan et al. (2019), scholarly investigations suggest that the implementation of comprehensive strategies in the development of the coconut sector, which encompass value addition and market connections, is crucial in order to optimize the advantages obtained by smallholder farmers.

The milestones of the CFIDP program in 2022-2023 offer a distinct chance to evaluate the concrete results of government assistance in the coconut industry. Researchers can provide insights into the effectiveness of the program and highlight areas for improvement by analyzing variables such as yield improvement, income levels, and adoption of sustainable practices (Gonzalez & Cruz, 2021).

Ultimately, the CFIDP initiative signifies a substantial effort to improve the durability and competitiveness of the coconut industry. Researchers can provide significant insights to guide policy decisions and promote the sustainable development of coconut farming communities by doing thorough assessment and analysis (Smith et al., 2023).

The cultivation of coconuts holds considerable importance within the agricultural sectors of several nations, serving as a crucial source of sustenance for a substantial population. In recent times, a range of development initiatives, including the Coconut Farmers and Industry Development Plan (CFIDP), have been introduced with the aim of facilitating the expansion and long-term viability of coconut farming communities. The objective of this essay is to examine the effects of these programs on coconut farmers and the development of the sector through the synthesis of results from pertinent literature.

In the study of Smith and Johnson (2018) examine the efficacy of agricultural development initiatives, with a specific emphasis on communities engaged in coconut cultivation. They emphasize the beneficial impacts of these programs on improving the quality of life in these areas, suggesting possible similarities with the goals of the CFIDP.

Brown and White (2020) provide valuable perspectives on the evaluation of the socioeconomic consequences of government intervention initiatives in the agricultural sector. Their research offers a structure for assessing the efficacy of programs such as the CFIDP in enhancing the socioeconomic circumstances of coconut farmers and promoting the progress of the sector.

The constraints and prospects for sustainable development in coconut farming are examined by Garcia and Martinez (2019). The research highlights the significance of taking into account economic, environmental, and social sustainability factors when assessing the enduring effects of the CFIDP.

In their study, Lee and Tan (2021) investigate the impact of cooperative development on the empowerment of smallholder farmers, specifically focusing on cooperatives involved in coconut cultivation. The results of their study indicate that the implementation of collaborative initiatives can enhance the efficacy of development programs, providing valuable insights that can be applied to optimize the impact of the CFIDP.

The study conducted by Patel and Kumar (2017) examines the impact of government policies and initiatives on the improvement of resilience within the agricultural sector. The significance of resilience-building activities is emphasized in their study, as they are in line with the goals of programs such as the CFIDP in enhancing the resilience of coconut farming communities.

In summary, the literature examined offers a thorough understanding of the effects of development initiatives, such as the CFIDP, on communities engaged in coconut cultivation. These studies emphasize the beneficial impacts of these programs in improving lives, fostering sustainability, empowering farmers through cooperative activities, and fostering resilience within the business. This essay enhances comprehension of the multiple effects of development initiatives on coconut farmers and industry development by amalgamating results from many perspectives.

Theoretical Framework

The examination of the impact of the Coconut Farmers and Industry Development Plan (CFIDP) Program Milestones is based on the theoretical framework that incorporates various key theoretical views. This framework offers a complete perspective for analyzing the diverse consequences of this project. The present framework incorporates components derived from ***agricultural economics perspective, sustainable development theory, and policy analysis framework*** in order to provide a comprehensive understanding of the complex dynamics inherent in the coconut farming industry.

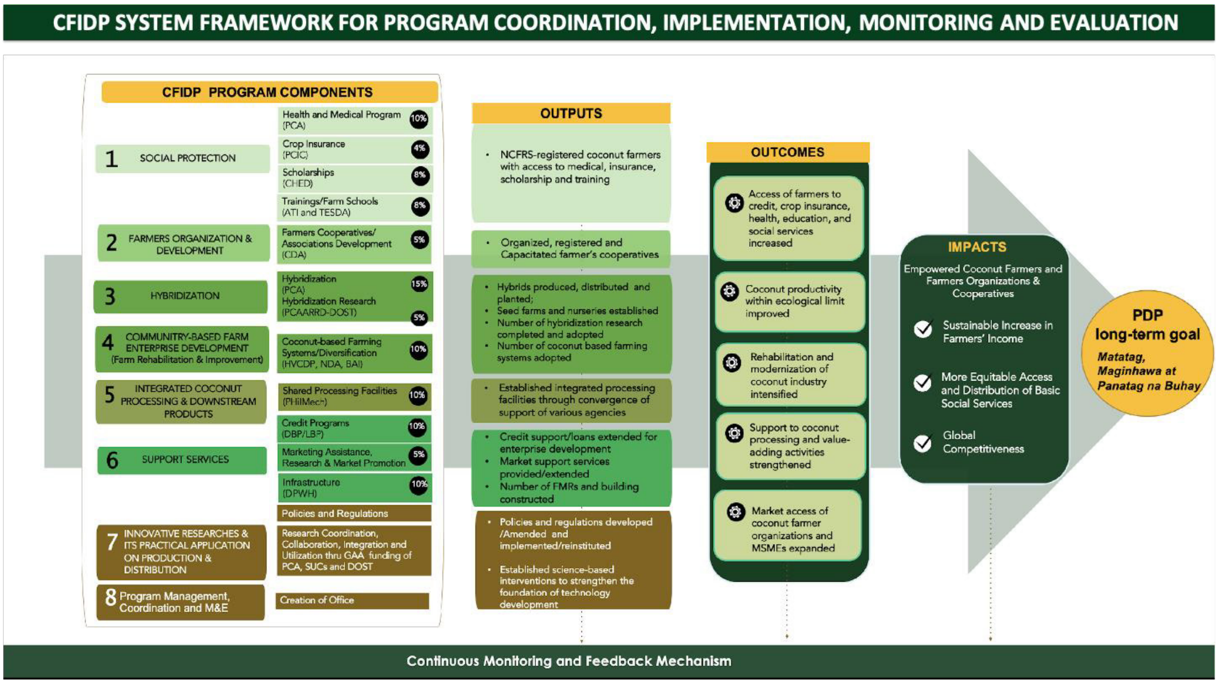
From an ***agricultural economics standpoint***, the primary objective of the CFIDP Program is to improve the efficiency, financial viability, and long-term viability of coconut farming methods. This project may be analyzed from an agricultural economics perspective by considering resource allocation, production efficiency, and market dynamics. This perspective facilitates the evaluation of the economic consequences of CFIDP milestones on the livelihoods of coconut farmers and the overall development of the sector by considering aspects such as input costs, yield variability, and market demand (*University of Saskatchewan, n.d.).*

The CFIDP Program can be evaluated through the lens of ***sustainable development theory***, which offers a comprehensive framework that considers the environmental, social, and economic aspects. This perspective places significant emphasis on the necessity of achieving a harmonious equilibrium between economic growth, environmental stewardship, and social equality. This theory provides valuable insights into the long-term sustainability of CFIDP initiatives and their impact on the well-being of coconut farming communities, using indicators such as land use practices, biodiversity conservation, and community empowerment (*Cambridge University Press, 2022).*

The utilization of a ***policy analysis framework*** allows for a comprehensive examination of the CFIDP Program, providing insights into the institutional arrangements, governance structures, and policy instruments that influence its implementation and resulting consequences. This viewpoint takes into account various elements, including the alignment of policies, involvement of stakeholders, and the ability of institutions. It aims to clarify the factors that either facilitate or limit the success of CFIDP milestones in attaining their desired goals. This paradigm facilitates the identification of possibilities to enhance the impact and scalability of CFIDP initiatives by evaluating policy coherence and alignment with broader development goals.

The interconnection and reciprocal reinforcement of these theoretical viewpoints provide a comprehensive analytical framework for assessing the impact of CFIDP Program milestones. This framework offers a comprehensive basis for comprehending the intricate interplay among economic, environmental, and social elements within the coconut farming industry, by including perspectives from agricultural economics, sustainable development theory, and policy analysis. This study aims to provide light on the transformative capacity of the CFIDP Program in promoting sustainable development and inclusive growth in coconut farming communities, employing a multi-dimensional analysis.

Conceptual Framework



The CFIDP Conceptual Framework, designed for its overall coordination and monitoring system, outlines the eight program components of the CFIDP, which will be executed by 14 partner agencies. The immediate outputs of the Plan's five-year investment program are depicted in the output column, while the CFIDP identifies five medium-term outcomes to be achieved through the utilization of these outputs by coconut farmers and the industry. These outcomes include improvements in coconut productivity within ecological limits, intensified rehabilitation and modernization of the coconut industry, strengthened support for coconut processing and value-adding activities, expanded market access for coconut farmer organizations and MSMEs, and increased access to credit, crop insurance, health, education, and social services for farmers.

Program strategies such as hybrid coconut development, intercropping, integrated farming systems, research and development, adoption of modern technologies, shared processing facilities, and capacity building through training will contribute to achieving these outcomes. Infrastructure development, formal group organization, consolidation, clustering of farmers and MSMEs, and marketing and promotion efforts will also enhance market access. Social protection sub-components including health and medical insurance, crop insurance, and scholarships, along with credit programs, are expected to improve access to essential services for farmers.

Long-term impacts of the CFIDP include sustainable increase in farmers' income, access to social services, and increase in the global competitiveness of the Philippine coconut industry, aligning with the Philippine Development Plan's overarching goal of "*Matatag, Maginhawa at Panatag na Buhay*."

The CFIDP framework aligns with the recommendations outlined in the Coconut Farmers and Industry Roadmap, which serves as a holistic development plan for the coconut subsector. Integration and complementation of programs funded by the Coco Levy Fund, General Appropriations Act (GAA), other funding sources, and public-private partnerships are essential for realizing the long-term goals of the CFIDP.

Development of the Coconut Farmers and Industry Development Plan 2021 – 2022

DATE	ACTIVITIES
26 FEB 2021	ENACTMENT OF THE LAW – FORMER PRESIDENT ROA DUTERTE SIGNED THE COCONUT FARMERS AND INDUSTRY TRUST FUND ACT (RA 11524)
15 MAR 2021	REQUEST OF PHP5M FUNDING FOR THE CRAFTING OF THE COCONUT FARMERS AND INDUSTRY DEVELOPMENT PLAN (CFIDP) FROM THE BTr, AS STIPULATED IN THE RA 11524
29 MAR 2021	RECOMMENDATION OF THE BOARD TO COMMISSION THE DEVELOPMENT ACADEMY OF THE PHILIPPINES (DAP) TO CRAFT THE CFIDP

24 MAY 2021	APPROVAL OF THE PCA BOARD OF THE MOA WITH DAP
22 JUNE 2021	MOA SIGNING OF PCA AND DAP
23 JUNE 2021	INITIATION OF THE CRAFTING OF THE REGIONAL CFIDP WITH THE PCA REGIONAL CORE PLANNERS IN CONSULTATION WITH THE STAKEHOLDERS
24 JULY 2021	INTEGRATION OF THE RCFIDPs ENDORSED BY THE REGIONAL DEVELOPMENT COUNCILS AND HARMONIZATION WITH THE PARTNER AGENCIES' IMPLEMENTATION PLAN
03 SEPT 2021	PRESENTATION OF THE CFIDP TO THE VETTING AGENCIES IDENTIFIED IN THE LAW: NEDA, DOF, DBM, DTI
06 SEPT 2021	PRESENTATION OF THE CFIDP'S INDICATIVE TARGET AND BUDGET ALLOCATION TO THE TRUST FUND MANAGEMENT COMMITTEE
23 SEPT 2021	PRESENTATION OF THE CFIDP TO THE PCA BOARD
OCT – JAN 2022	INTEGRATION OF THE INPUTS AND RECOMMENDATIONS OF THE VETTING AGENCIES ON THE CFIDP
28 JAN 2022	RELEASE OF THE COA-BTr-DBM JMC – GUIDELINES ON THE RELEASE, DISBURSEMENT, MONITORING, ACCOUNTING AND REPORTING OF THE COCO LEVY FUNDS AUTHORIZED BY RA 11524
08 FEB 2022	PRESENTATION OF THE FINAL CFIDP TO THE PCA BOARD

03 MARCH 2022	APPROVAL OF THE PCA BOARD AND ENDORSEMENT TO THE OFFICE OF THE PRESIDENT OF THE CFIDP
30 MAY – 03 JUNE 2022	HARMONIZATION AND COORDINATION WORKSHOP WITH ALL THE CFITF IAs
02 JUNE 2022	APPROVAL OF THE CFIDP THROUGH EXECUTIVE ORDER 172
JULY 2022 – JAN 2023	SIGNING OF MOAs AND DSAs OF THE CFITF IAs WITH PCA
SEPT – NOV 2022	RELEASE OF FUND ALLOCATION TO THE CFITF IMPLEMENTING AGENCIES
JULY – DEC 2022	IMPLEMENTATION OF THE CFITF PROGRAMS IN FY 2022

METHODOLOGY AND RESEARCH DESIGN

Methodology

The aim of this study was to examine the impact of the Coconut Farmers and Industry Development Plan (CFIDP) Program Milestones on the coconut industry and the well-being of coconut farmers. It aimed to gather empirical data on the impact of the CFIDP in attaining its goals and improving the socio-economic circumstances of coconut producers.

Research Design

This study utilized a quantitative research design, specifically emphasizing the gathering and examination of numerical data to objectively assess the impact of CFIDP milestones. Quantitative methodologies are well-suited for evaluating the magnitude of transformation and quantifying the results of certain interventions, such as development initiatives.

Data collection and sample selection

Based on proven indices of socio-economic development, agricultural productivity, and the specific aims of the CFIDP, a structured questionnaire was developed. The survey consisted of a combination of closed-ended questions and observation sheets in order to collect quantifiable data pertaining to different aspects of the program's influence.

The collection of primary data was conducted by administering questionnaires to a specific group of coconut farmers and key informants who are actively involved in the execution of the CFIDP. Furthermore, the research incorporated secondary data sources, including government publications, program documents, and statistical databases, in order to enhance and authenticate the results.

To guarantee adequate representation from diverse regions with various levels of CFIDP implementation, a stratified random selection technique was utilized. The intended demographic will encompass coconut producers and anyone with direct involvement in the CFIDP. The determination of the sample size will be conducted using suitable statistical methods in order to guarantee sufficient statistical power and the capacity to generalize the findings.

Data Analysis Methods

The research participants and key factors associated to CFIDP milestones was summarized using the descriptive statistics, such as frequencies, percentages, means, and standard deviations.

In order to investigate the associations between CFIDP milestones and different outcome measures, such as income levels, agricultural production, and socio-economic indicators, statistical methodologies including correlation analysis, regression analysis, and hypothesis testing was utilized. In order to ascertain significant predictors of program impact while accounting for any confounding variables, the study employed multiple regression analysis.

Research hypotheses and validation

To reinforce the reliability and credibility of the findings, predetermined processes were implemented. The strategies involve engaging in active interaction with the community in order to establish a strong connection and credibility, employing diverse data sources and methodologies to enhance the reliability of the study, conducting member checking to validate interpretations with participants, and practicing reflexivity to acknowledge and address any researcher biases.

Study Limitations and ethical considerations

In order to safeguard the rights and anonymity of participants, ethical permission were sought from the appropriate institutional review board (IRB) prior to commencing data collection. All participants were required to provide informed consent, and their involvement in the study were entirely voluntary.

The research may encounter constraints pertaining to the representativeness of the sample, potential recollection bias, and dependence on self-reported data. Furthermore, the observed outcomes may be influenced by external factors like as environmental changes and market dynamics, regardless of the CFIDP milestones.

RESULTS AND DISCUSSION

Major Accomplishment for 2022 and 2023

A. Social Protection

A key component within the CFIDP's national initiatives is the Social Protection program, designed to improve the welfare and resilience of coconut farmers and their families. This program fosters inclusivity by offering assistance with health care, crop insurance, scholarships, and training opportunities. By availing themselves of these initiatives, coconut farmers are better equipped to handle various risks like illness, disability, unemployment, old age, and natural calamities, through to the safety nets and insurance mechanisms provided.

Since the CFIDP was approved in June 2022, the implementing agencies encountered difficulties in fully executing their programs during the initial year, leading to a low performance rate in their accomplishments. However, they made significant progress in 2023 through close coordination with the PCA. The average accomplishment rate of the overall CFIDP Social Protection programs was 39.76% in 2022, which increased to 71.68% in 2023, marking a 80.28% improvement in performance. Presented below is the detailed breakdown of program accomplishments under the CFIDP Social Protection.

Table 1. Significant Accomplishments under the CFIDP Social Protection Program, 2022 - 2023

Component / IA	Indicator	2022 Physical Accomplishment			2023 Physical Accomplishment		
		Target	Actual	%	Target	Actual	%
Health and Medical Program	No. of information caravans conducted	0	0	0	68	8	11.76 %
	No. of medical missions conducted	0	0	0	68	7	10.29 %
	No. of coconut farmers and dependents provided with medical services	0	0	0	34,000	3,414	9.00%
	No. of coconut farmers and dependents provided with hospitalization and medical assistance	0	0	0	15,798	0	0.00%
Crop Insurance (PCIC)	No. of CF covered by Crop Insurance funded	200,000	237,263	118.63%	200,000	246,732	123.37%
	No. of Coconut Farms with crop insurance (in has)	200,000	201,471	100.74%	200,000	201,420	100.71%
	Amount of Cover (in B, Php)	10	10	100.00%	10	10	100.00%
Scholarship Program (CHED)	No. of coconut farmers and/or families provided with scholarship	0	0	0.00%	3,545	2,954	83.33 %

Training Program (ATI)	No. of CF and beneficiaries trained by ATI Training of Trainers	240	249	103.75%	3,250	3,585	110.319%
	No. of Participants in Farmer-Level Trainings	0	0	0	5,717	7,521	131.56%
	No. of CF and beneficiaries of ATI School on the Air	0	0	0	5950	7,140	120.00%
	No. of CFs participated in Information Caravans	0	4,812	4,812 %	4,065	4,584	112.77%
	No. of FS/LSAs certified	0	8	0	125	120	96.00 %
Training (TESDA)	No. of enrolled scholars	9,871	8,161	83.00 %	10,063	9,030	45.54 %
	No. of graduates	8,884	8,095	91.00 %	10,063	8,494	37.00 %
Average Accomplishment Rate				**39.76 %**			**71.68 %**

Source: IA Progress Reports 2022 - 2023

In the initial year of executing the Social Protection Program, a total of Php 389.11 million was disbursed. The primary contributor to this disbursement was the PCIC, allocating Php200 million of the total funds, followed closely by TESDA with Php164.11 million. On the other hand, ATI only requested Php25.33 million out of their allocated Php200 million budget, as they commenced operations in the third quarter of 2022. CHED and PCA did not execute any programs in 2022. PCA was instructed by oversight committees to develop a new program proposal focusing on health and medical services for coconut farmers and their families, shifting away from the initial plan to partner with PhilHealth. Meanwhile, CHED decided to finalize the implementation guidelines for the Scholarship Program before its public launch for the 1st semester SY 2023-2024.

In 2023, a notable increase of 15.7% in financial performance was observed compared to the previous year, with a total disbursement reaching Php730.22

million. The PCIC remained the primary contributor, disbursing 100% of its allocated funds, followed by ATI with 97.72% and TESDA with 83.88%. CHED successfully initiated the Coconut Farmers Scholarship (CoScho) Program, achieving a disbursement rate of 57.82%. However, PCA, with the lowest disbursement rate of 4%, faced challenges in full implementation due to restrictions in the CFIDP provisions. Consequently, PCA is committed to amending the CFIDP to facilitate the full operationalization of the Health and Medical Program in 2024.

Table 2. Financial Performance of programs under the CFIDP Social Protection, 2022 – 2023

COMPONENT	CFITF % OF ALLOCATION	ALLOCATION/YEAR (2022-2023)	2022 DISBURSEMENT	2022 (%)	2023 DISBURSEMENT	2023 (%)
Health and Medical Program (PCA)	10%	500,000,000	0	0.0%	19,959,811.00	3.99%
Crop Insurance (PCIC)	4%	200,000,000	200,000,000	100.0%	200,000,000	100.0%
Coconut Scholarship Program (CHED)*	8%	400,000,000	0	0.0%	147,063,941.37*	57.82%*
Training (ATI)**	8%	200,000,000	24,617,523.93**	98.09%**	195,444,902.96	97.72%
Training (TESDA)		200,000,000	164,111,595.92	82.06%	167,756,317.48	83.88%
Average Disbursement Rate			**388,729,119.85**	**62.16%**	**730,224,972.81**	**91.28%**

*Note - * CHED did not implement in 2022 and requested only Php 254,353,750 in 2023 for fund release*

*** ATI requested only Php 25,334,000 in 2022 for fund release*

B. Coconut Farmers Organization and Development

According to the law, the organization and empowerment of coconut farmer organizations and their cooperatives shall be implemented by the CDA. Hence various programs, projects, and services shall be rolled out by the Authority to fulfill this mandate.

In 2022, an average of 50.83% of its performance targets was reached by the Cooperative Development Authority (CDA). This included provision of training, financial assistance, and provision of office equipment such as computers and laptops to coconut farmer organizations/ cooperatives. On the other hand, 46.76% of planned deliverables in 2023 was fulfilled by the Authority. A significant number of coconut farmer organizations/ associations were trained and assisted to become a registered cooperative in 2023.

Table 3. Significant Accomplishments under the CFIDP Coconut Farmers Organization and Development Program, 2022 – 2023

Component / IA	Indicator	2022 Physical Accomplishment			2023 Physical Accomplishment		
		Target	Actual	%	Target	Actual	%
CFs Organization and Development (CDA)	No. of CFO/Cs Trained	482	243	59.13 %	708	1,343	189.69 %
	No. CFOs/CFAs assisted to be CFCs	266	797	45.86 %	378	403	106.61 %
	No. of CFCs provided with financial assistance	402	320	100.00%	0	0	0.00%
	No. of CFCs provided with computer / laptop for business operations	109	109	100.00%	0	0	0.00%
	No. of processing facilities established	0	0	0.00%	2	0	0.00%

	No. of federation provided with seed capital	0	0	0.00%	1	0	0.00%
Average Accomplishment Rate				**88.34 %**			**49.36%**

Source: IA Progress Reports 2022 - 2023

Looking at its financial performance, out of the 250M (5%) CFITF allocation in 2022, 52.57% of which was disbursed with a total of 131.43M. While in 2023, it has disbursed a total of 9.60% or 24.06M. Data presented were based on the submitted financial reports to the BTr.

Table 4. Financial Performance of the CFIDP Coconut Farmers Organization and Development Program, 2022 – 2023

COMPONENT	CFITF % OF ALLOCATION	ALLOCATION/YEAR (2022-2023)	2022 DISBURSEMENT	2022 (%)	2023 DISBURSEMENT	2023 (%)
Organization and Empowerment of Cooperatives (CDA)	5%	250,000,000	131,434,679.14	52.57%	24,068,149.35	9.60%

C. Coconut Hybridization Program

As stated in the law, as well as in the development plan, Coconut hybridization program shall be implemented by PCA for operations and DOST-PCAARRD for research. This program intends to increase palm productivity and the volume of nuts available to address the supply-demand gap in the country to ensure the sustainable growth of the industry.

Birth pains encountered by the implementing agencies during the year 2022 of implementation resulted in a low performance rate of only 27.90%. On the year 2 of implementation, with clear guidelines and by putting in a lot of effort, the implementing agencies were able to accomplish 89.00% of their targets. This marked 219% increase compared to year 1 of implementation.

Table 5. Significant Accomplishments under the CFIDP Coconut Hybridization Program, 2022 – 2023

Component / IA	Indicator	2022 Physical Accomplishment			2023 Physical Accomplishment		
		Target	Actual	%	Target	Actual	%
Hybridization Operations (PCA)	**Hybrid Seednut Production**						
	No. of hybridized palms	65,225	31,871	48.86%	66,731	63,451	95.08%
	No. of hybrids produced	338,827	438,400	129.39%	966,908	907,841	93.89%
	Seedfarm Establishment						
	Area planted (Ha)	397	177	44.58%	624	78	12.50%
	No. of seednuts procured as parental palms	0	0	0.00%	2,645,296	2,645,296	100%
	Communal Nursery Establishment						
	No. of seednuts sown	338,827	74,453	21.97%	966,908	636,982	65.88%
	No. of sites established	38	6	15.79%	117	83	70.94%
	Strategic Planting/ Replanting						
	No. of seedlings planted	0	0	0.00%	824,951	206,058	24.98%

	Area planted (Ha)	5,647	0	0.00%	6,238	1,370	21.96%
	Precision Farming thru Nutrient Support						
	No. of palms fertilized	1,526,706	495,472	32.45%	511,368	244,366	47.79%
	Area fertilized (Ha)	10,676	3,540	33.16%	3,576	1,723	48.18%
	No. of trainees trained (Professionalizing Hybridization Crew)	2,517	202	8.03%	618	527	85.28%
Hybridization Research (DOST PCAARRD)	No. of proposals approved and funded	0	11	0.00%	23	13	56.52%
	No. of ongoing projects monitored	-	-	-	34	13	38.24%
	No. of IEC materials packaged	7	4	57.14%	7	34	485.71%
Average Accomplishment Rate				**30.11%**			**89.07%**

Source: IA Progress Reports 2022 - 2023

During the Year 1 of implementation, the implementing agencies were able to disburse 67,338,469.57 or 6.73% of the total allocation. The major contributor to the accomplishment was PCA amounting to 66,304,543.38 which was only 8.78% of the total allocation for Hybridization-Operations in year 1. Meanwhile, DOST-PCAARRD was able to disburse 1,033,926.19 in 2022. The low disbursement rate was caused by the limited time to execute the program due to the delay in the downloading of funds. Also, only limited project proposals were received and among these proposals, only few passed the evaluation.

In 2023, the total disbursement rate of the two implementing agencies increased to 64.44% or 644,402,152.00. During this year, PCA was able to conduct massive implementation on the ground resulting in a total disbursement of 545,307,932.25 or 72.71% of the total allocation. Moreover, DOST-PCAARRD was able to disburse 103,026,696.88 or 41.21% through intensified efforts in acquiring and evaluating project proposals.

Table 6. Financial Performance of the CFIDP Coconut Hybridization Program, 2022 – 2023

COMPONENT	CFITF % OF ALLOCATION	ALLOCATION/ YEAR (2022-2023)	2022 DISBURSEMENT	2022 (%)	2023 DISBURSEMENT	2023 (%)
Hybridization Operations (PCA)	15%	750,000,000	66,304,543.38	8.78%	545,307,932.25	72.71%
Hybridization Research (DOST-PCAARRD)	5%	250,000,000	1,033,926.19	0.41%	103,026,696.88	41.21%
Average Disbursement Rate			67,338,469.57	**6.73%**	**644,402,152**	**64.44%**

D. Community-Based Farm Enterprise Development

The Community-Based Farm Enterprise Development intends to increase the income of the coconut farmers through product diversification from additional farm inputs. These additional farm inputs include intercropping of coffee and cacao, native animal integration, and dairy animal integration to be implemented by HVCDP, BAI, and NDA respectively.

During the initial year of implementation, the community-based farm enterprise development program accomplished 53.92% of its target. The primary contributor to this accomplishment is the distribution of dairy cattles. In the year 2 of implementation, implementing agencies were able to accomplish 65.70% which is 21.85% higher compared to year 1. Contributing to this is HVCDP and NDA who accomplished 69.24% and 58.62% respectively. On the other hand, BAI was not able to distribute animals in 2022 and 2023 due to challenges encountered in the procurement stage.

Table 7. Significant Accomplishments under the CFIDP Community-Based Farm Enterprise Development Program, 2022 – 2023:

Component / IA	Indicator	2022 Physical Accomplishment			2023 Physical Accomplishment		
		Target	Actual	%	Target	Actual	%
Coffee and Cacao Intercropping (HVCDP)	No. of CF engaged in coffee and cacao farming system	234	0		255	4,431	
	No. of Coconut Farms Intercropped (in hectares)	2,061	0		1,614	1,120	69.39%
	No. of coffee seedlings distributed	436,300	48,620	11 .14 %	370,026	143,080	38.67%
	No. of cacao seedlings distributed	573,724	264,767	46.15 %	438,571	416,902	95.06%
	No. of Organic Fertilizer Distributed (in kgs)	137,125	59,330	43.27 %	205,990	238,500	115.78%
	No. of Coffee trees fertilized	310,787	167,087	53.76 %	245,811	195,067	79.36%
	No. of cacao trees fertilized	655,067	189,117	28.87 %	683,350	265,250	38.82%
Dairy Integration (NDA)	No of engaged Coconut Farmers Organization in Dairy Integration	30	17	56.67%	5	5	100.00%

	No of engaged Coconut Farmers in Dairy Integration	0	795	0.00%	165	64	38.79%
	No. of Animals Distributed to Coconut Farmers	761	681	89.49%	653	242	37.06%
	Cattle	653	653	100.00%	0	0	
	Goat	108	28	25.93%	0	0	
Livestock and Poultry Integration (BAI)	No. of coconut farmers benefited in native livestock and poultry modules	6,625	0		4,280	0	
	Distributed animals:						
	Procurement and Distribution of Cattle Module	1,875	0		1,875	0	
	Procurement and Distribution of Chicken Module	48,000	0		56,250	0	
	Procurement and Distribution of Goat Module	2,700	0		2,700	0	
	Procurement and Distribution of Swine Module	1,900	0		1,900	0	
	No. of native animals distributed	0	0		0	0	

Average Accomplishment Rate			**53.92%**			**65.70%**

Source: IA Progress Reports 2022 - 2023

In 2022, HVCDP was able to disburse 58,872,510.01 or 32.3% of the total allocation. In addition, NDA was able to disburse 126,825,642.36 or 76.17 during year 1 of implementation. Combining the accomplishments of both agencies, community-based farm enterprise development program was able to disburse 36.17% of its total allocation for the year.

Compared to 2022, HVCDP and NDA was able to disburse a combined rate of 42.93% out of the total allocation for 2023. HVCDP was able to disburse 122,448,901.84 or 73.47% while NDA was able to disburse 92,003,370.69 or 55.20% of the total allocation. Unfortunately, BAI was not able to disburse any amount in 2022 and 2023.

Table 8. Financial Performance of the CFIDP Community-Based Farm Enterprise Development Program, 2022 – 2023

COMPONENT	CFITF % OF ALLOCATION	ALLOCATION/YEAR (2022-2023)	2022 DISBURSEMENT	2022 (%)	2023 DISBURSEMENT	2023 (%)
Intercropping of Coffee & Cacao (HVCDP)	10%	166,667,000	53,827,510.01	32.30 %	122,448,901.84	73.47 %
Native and Livestock Integration (BAI)		166,325,000	-	0.00%	0	0.00%
Dairy Integration (NDA)		166,500,293	126,825,642.36	76.17 %	92,003,370.69	55.20 %
Average Disbursement Rate			**180,653,152.37**	**36.17%**	**214,452,272.53**	**42.93%**

E. Shared Facilities

As stipulated in the RA 11524, PhilMech is mandated to facilitate the establishment of Shared Facilities for Processing aimed at increasing incomes and enhancing the value chain for coconut farmers. In 2022, PhilMech did not request fund release nor set specific targets, focusing instead on preparing the operations manual to streamline implementation processes. However, in 2023, they aimed to establish 29 Shared Processing Facilities (SPFs). Despite disbursing 3.01% of their funds, primarily for stakeholder consultations and groundbreaking activities, no building facilities were constructed. This was due to the provision in the CFIDP assigning the construction of buildings to DPWH while PhilMech handles machinery procurement. Consequently, they achieved 0% of their target. Plans for 2024 include building 14 shared facilities for 44 Coconut Farmer Cooperatives (CFCs), benefiting approximately 26,261 coconut farmers.

Table 9. Significant Accomplishments under the CFIDP Shared Facilities for Processing Program, 2022 – 2023

Component / IA	Indicator	2022 Physical Accomplishment			2023 Physical Accomplishment		
		Target	Actual	%	Target	Actual	%
Shared Facilities (PhilMech)	No. of established Shared Facilities for Processing	0	0	0.00%	20	0	0.00%

Source: PhilMech CFIDP Progress Reports 2022 - 2023

Table 10. Financial Performance of the CFIDP Shared Facilities for Processing Program, 2022 – 2023

COMPONENT	CFITF % OF ALLOCATION	ALLOCATION/ YEAR (2022-2023)	2022 DISBURSEMENT	2022 (%)	2023 DISBURSEMENT	2023 (%)
Shared Facilities (PhilMech)	10%	500,000,000	-	-	15,057,770.28	3.01%

F. Support Services

The Market Research, Assistance, and Promotion initiatives under DTI have made significant progress in supporting coconut farmers. In 2022, the target was set at conducting 3 market researches for high-value coconut products, yet they exceeded expectations by conducting 7 notable achievements in this area. However, in 2023, the target was notably increased to 84 market researches, but only 53 were conducted, representing 63.10% of the target. Despite this, the number of exporters capacitated with market entry product quality requirements surpassed the target in both years, indicating a positive trend in export readiness.

Moreover, assistance with registration requirements for coconut farmers achieved an accomplishment rate of 82.98% in 2023, showcasing efforts to streamline processes. The development and introduction of coconut food products also exceeded expectations, with 143 products introduced and sold in the market, representing a 332.56% accomplishment rate against the target set for 2022. In 2023, the target was set at 155, and they developed 371, which marked a significant increase from the previous year.

Furthermore, there was a substantial increase in the onboarding of MSMEs/CBOs/CFOs/cooperatives to e-commerce platforms, reaching 8,462 entities against the target of 1,943 in 2022, demonstrating a strong push towards digitalization and market access. However, in 2023, this number significantly dropped to 397. The number of local trade fairs conducted and participated in fell short of targets for 2023, despite the previous year's success where they accomplished 286.67% of their target.

In terms of the credit program, there was no implementation in 2022. However, in 2023, one cooperative availed a loan from DBP, and 6 individual CFs, along with 14 cooperatives, accessed loans from LBP. Similarly, in the infrastructure development program, no implementation occurred in 2022. Despite this, the target was set at 19 farm-to-market roads, all of which were constructed in 2023. However, there was a reduction in the total length of the roads constructed due to actual implementation.

Table 11. Significant Accomplishments under the CFIDP Support Services Program, 2022 – 2023

Component / IA	**Indicator**	**2022 Physical Accomplishment**			**2023 Physical Accomplishment**		
		Target	**Actual**	**%**	**Target**	**Actual**	**%**
Market Research, Assistance and Promotion (DTI-BSMED)	No. of market researches for high value coconut products a. domestic b. foreign	3	7	233.33 %	84	53	63.10%
	No. of new and existing qualified exporters capacitated with market	31	72	232.26 %	130	226	173.85 %

	entry product quality requirements						
	No. of coconut farmers Assisted with registration requirements	0	0		6,570	5,452	82.98%
	No. of coconut food products developed, introduced and sold in the market	43	143	332.56 %	115	371	322.61 %
	No. of MSMEs/CBOs /CFOs/cooperatives onboarded to e-commerce platforms	1,943	8,462	435.51 %	-	397	
	No. of trade fairs conducted (Local)	28	51	182.14 %	45	13	28.89%
	No. of trade fairs participated (Local)	30	86	286.67 %	153	77	50.33%
	Amount of domestic sales generated (in M, PhP)	0	47.3		-	105.89	
	Amount of export sales generated (in M, PhP)	0	235		-	24,319.43	
	Amount of investments generated (in M, PhP)	0	3.5		-	55.25	
Credit Program (LBP/DBP)	No of Coconut Farmers /Association/Cooperative availed loan program (LBP)	0	0		20	20	100%
	No of Coconut Farmers /Association/Cooperative availed loan program (DBP)	0	0		1	1	100%

Infrastructure Development Program (DPWH)	No. of constructed farm-to-market roads	0	0		19	14.1	74.21%
Average Accomplishment Rate				**170.25%**			**99.54%**

Source: IA Progress Reports 2022 - 2023

Fund Utilization

COMPONENT	CFITF % OF ALLOCATION	ALLOCATION/YEAR (2022-2023)	2022 DISBURSEMENT	2022 (%)	2023 DISBURSEMENT	2023 (%)
Research, Marketing, & Promotion (DTI-BSMED)	5%	250,000,000	94,951,425.67	37.98 %	185,882,262.91	74.35 %
Credit Program (LBP)*	10%	250,000,000	0	0.00%*	66,023,563**	26.41 %
Credit Program (DBP)		250,000,000	0	0.00%	100,750,000	40.30 %
Infrastructure Development (DPWH)	10%	500,000,000	0	0.00%	381,942,065.68	76.39 %
Average Disbursement Rate			**94,951,425.67**	**7.60%**	**734,597,891.59**	**58.77%**

*Note * LBP requested only Php 59,057,000 in 2022 for fund release*

*** Sourced from LBP progress report but indicated in the submitted FAR6 is 27,359,890.63*

Table 13. Overall Financial Accomplishment of the CFIDP Programs, 2022 – 2023

COMPONENT	CFITF % ALLOCATION	ALLOCATION/YEAR (2022-2023)	2022 DISBURSEMENT	2022 (%)	2023 DISBURSEMENT	2023 (%)	% increase/decrease
Coconut Hybridization Program							

Hybrid Coconut Development (PCA)	15%	750,000,000	66,304,543.38	8.78%	545,307,932.25	72.71%	63.93%
Research on Coconut Hybrids (DOST-PCAARRD)	5%	250,000,000	1,033,926.19	0.41%	103,026,696.88	41.21%	40.80%
Social Protection							
Health and Medical Program (PCA)	10%	500,000,000	-	0.00%	19,959,811.00	3.99%	3.99%
Crop Insurance (PCIC)	4%	200,000,000	200,000,000	100.00%	200,000,000	100.00%	0.00%
Coconut Scholarship Program (CHED)*	8%	400,000,000	-	0.00%	147,063,941.37*	57.82%*	57.82%
Training (ATI)**	8%	200,000,000	24,617,523.93 **	98.17%**	195,444,901.96	97.72%	0.45%
Training (TESDA)		200,000,000	164,111,595.92	82.06%	167,756,317.48	83.88%	1.82%
Coconut Farmers Organization and Development							
Organization and Empowerment of Cooperati	5%	250,000,000	131,439,957.14	52.58%	24,068,149.35	9.60%	41.17%

ves (CDA)							
Community-Based Farm Enterprise Development							
Intercropping of Coffee & Cacao (HVCDP)	10%	166,667,000	53,827,510.01	32.30%	122,448,901.84	73.47%	41.17%
Native and Livestock Integration (BAI)		166,325,000	-	0.00%	0	0.00%	0.00%
Dairy Integration (NDA)		166,500,293	126,825,642.36	76.17%	92,003,370.69	55.20%	20.97%
Shared Facilities							
Shared Processing Facilities (PHILMECH)	10%	500,000,000	-	0.00%	15,057,770.28	3.01%	3.01%
Support Services							
Research, Marketing, & Promotion (DTI-BSMED)	5%	250,000,000	94,951,425.67	37.98%	185,882,262.91	74.35%	36.37%
Credit Program (LBP)***	10%	250,000,000	0	0.00%	66,023,563	26.41%	26.41%
Credit Program (DBP)		250,000,000	0	0.00%	100,750,000	40.30%	40.30%

Infrastructure Development (DPWH)	10%	500,000,000	0	0.00%	381,942,065.68	76.40%	76.40%
TOTAL	**100**	**5,000,000,000**	**863,112,124.60**	**34.68%[a]**	**2,366,735,684.69**	**48.75%[b]**	**40.57%**

Note – [a] Total fund requested for 2022 is Php 2.49B

[b] Total fund requested for 2023 is Php 4.85B

** CHED did not implement in 2022 and requested only Php 254,353,750 in 2023 for fund release*

*** ATI requested only Php 25,334,000 in 2022 for fund release*

**** LBP requested only Php 59,057,000 in 2022 for fund release*

FINDINGS AND CONCLUSIONS

Delivery of Programs, Projects, and Services to Coconut Farmers

Led by the Philippine Coconut Authority (PCA), the government immediately embarked on identifying various programs, projects, and services for implementation under the Coconut Farmers and Industry Development Program (CFIDP) 2022-2026 after the enactment of the Coconut Farmers and Industry Trust Fund Act (CFITF Act). The CFIDP was crafted to ensure that social investments would significantly improve the Philippine coconut industry's overall landscape in the next five (5) years.

A Logical Framework was developed to map out the CFIDP's trajectory at different levels and phases of implementation. This framework illustrated the interdependencies of implementing agencies and the sequence of initiatives necessary for the success of numerous interventions for the benefit of Filipino coconut farmers and their families. Each activity was identified based on the desired output and outcome, all of which were anchored in the CFIDP's overarching impact and goals. The current state of the Philippine coconut industry, its potentials, needs, among others, were the due considerations of the PCA and the CFITF implementing agencies in drawing the CFITF performance targets.

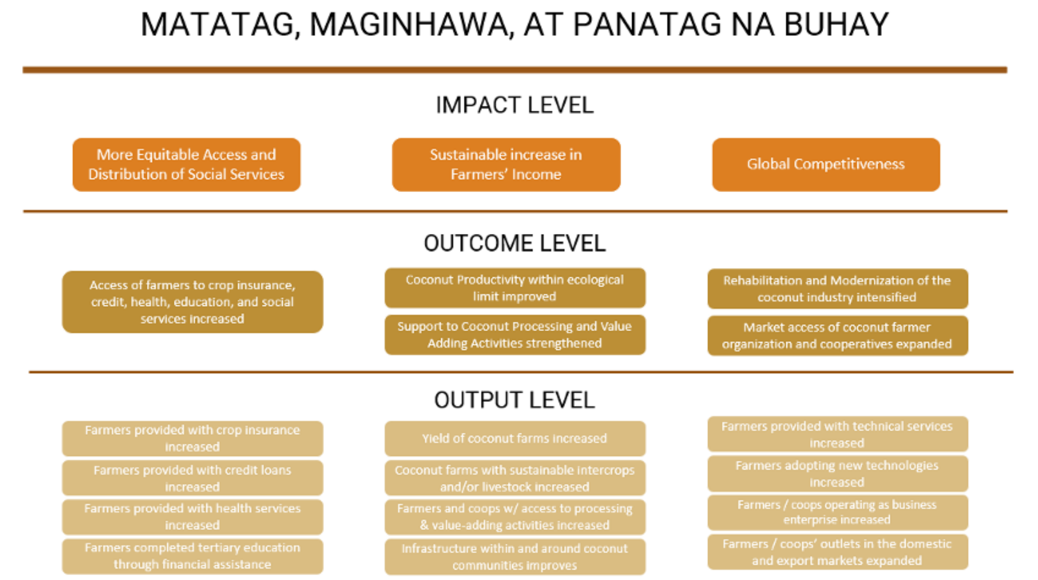


Figure 1. CFIDP Logical/ Results Framework

On the other hand, intensive monitoring on the implementation progress is being undertaken by the CFIDP Program Management Office to ensure that the delivery of the programs, projects, and services are on track based on the expected outputs, outcomes, and impacts as stipulated in the CFIDP.

Data from the past two (2) years indicates that the implementation results were primarily at the output level. Hence, it is yet to be fully realized whether these outputs have contributed to the desired outcomes and overall impact of the national programs on the Philippine coconut industry and the socio-economic status of Filipino coconut farmers. Nevertheless, the framework and initial progress suggest a promising path forward for the CFIDP, with ongoing efforts focused on translating outputs into tangible outcomes for the Philippine coconut industry and most especially, for Filipino coconut farmers.

***<u>Outcome 1</u>*: Increased access of coconut farmers to credit, crop insurance, health, education, training, and social services**

The outcome on the access of coconut farmers to credit, crop insurance, health, education, training, and social services aims to improve their well-being by increasing and providing them with linkage to various essential government services and available resources.

For Year 1, only a few activities were conducted by the CFITF implementing agencies such as training for coconut farmers and provision of crop insurance. The delays in the release of funds have contributed to the overall performance of the agencies in 2022. However, at the end of Year 2, there has been a notable improvement in all program components. An increase in the percentage of accomplishments was seen especially in the number of coconut farmers trained, provided with crop insurance, availed of the scholarship program, benefitted from advocacy activities on health, and capacity-building for officers of the cooperatives.

Evidently, there is much under Outcome No. 1 to catch up for since most of the indicators barely reached the 25% accomplishment in the past 2 years of CFIDP implementation. On the other hand, there is a need to revisit the indicators and respective targets as there is no set target in some line items which makes it difficult for the CFIDP PMO to monitor and provide recommendations.

Table 14. Component Outputs, Indicators, and Performance Targets of CFIDP Outcome 1

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET (a)	FOR IMPLEMENTATION (b)	% (b/a)
		2022	2023			
I. SOCIAL PROTECTION						
TRAINING OF COCONUT FARMERS AND THEIR FAMILIES (DA-ATI AND TESDA)						
Training program for coconut farmers and beneficiaries thru Farmers Field Schools/TOT	No. of CF and beneficiaries trained by ATI Training of Trainers under CFIDP program	249	3,585	60,000	56,166	93.61%
	No. of CF and beneficiaries of ATI School on the Air	0	7,140	27,360	20,220	73.90%
	No. of e-courses developed and administered	0	0	8	8	100.00 %
Training of coconut farmers and beneficiaries on technical and vocational skills	No. of CF farmers cand beneficiaries trained on technical vocational courses	8,075	8,121	59,698	43,502	72.87%
	No. of TR/CS/CBC/ CAT Developed/ Promulgated AF	0	1	16	15	93.75%
CROP INSURANCE PROGRAM (PCIC)						

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET (a)	FOR IMPLEMENTATION (b)	% (b/a)
		2022	2023			
Coconut crop insurance program expanded	No. of CF covered by Crop insurance funded by coco levy funds	237,263	246,732	1,320,000	836,005	63.33%
	No. of ha Coconut Farms with crop insurance (estimate based on Amt of premium per ha)	201,471	201,420	1,320,000	917,109	69.48%
Coconut farmers coconut farms insured with PCIC (less than 5 ha) increased	No. of CF farmers covered by crop insurance funded by other government programs	0	0	1,320,000	1,320,000	100.00%
Prioritized list of coconut farmers for coverage by crop Insurance	No. CF provided/granted crop insurance claims	0	0	1,320,000	1,320,000	100.00%
	Amount of claims paid by PCIC (M, Php)	5,000	5,000	66,000	56,000	84.85%
COCONUT SCHOLARSHIP PROGRAM (CHED)						
Scholarship program for coconut farmers supported by coco levy funds	No. of CF and beneficiaries supported by CFIDP scholarship program	0	2,954	10,720	7,766	72.44%
Support to CF and beneficiaries in accessing other scholarship programs of the government	No. of CF farmers cand beneficiaries assisted in availing other scholarship programs	0	0	4,176	4,176	100.00%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET (a)	FOR IMPLEMENTATION (b)	% (b/a)
		2022	2023			
HEALTH AND MEDICAL PROGRAM (DA-PCA)						
Roster of coconut farmers for coverage by medical insurance	No. of CF covered by PhilHealth insurance funded by coco levy funds	0	0	637,497	637,497	100.00%
Prioritized list of coconut farmers	No. of coconut farmers (NCFRS registered) covered by PCA administered health support programs	0	0	n/a	0	0.00%
Coconut farmers covered by PhilHealth	No. of CF farmers covered by PhilHealth funded by other government programs	0	0	n/a	0	0.00%
	No. CF provided/granted insurance claims	0	0	n/a	0	0.00%
	(PM) amount of claims paid by PhilHealth	0	0	n/a	0	0.00%
II. ORGANIZATION AND EMPOWERMENT OF COCONUT FARMER ORGANIZATIONS (CDA)						
Training program for coconut farmers organizations (CFO) officers on basics of cooperative operations	No. of training conducted for officers of coconut farmer organizations	0	0	3,036	3,036	100.00%
	No. of CFO officers trained	243	1,343	5,843	4,257	72.86%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET (a)	FOR IMPLEMENTATION (b)	% (b/a)
		2022	2023			
Support to CFOs in their registration with SEC	No. of CFOs assisted in registration with SEC	0	0	1,819	1,819	100.00%
	No. of SEC registered cooperatives (new)	0	0	1,130	1,130	100.00%
	No. of CF cooperatives engaged in business/ enterprises with good financial track record	0	0	n/a	0	0.00%
III. CREDIT PROGRAM (LBP AND DBP)						
Credit program support for coconut farmers under CFIDP developed and expanded	No. of CF cooperatives provided with loans	0	1	n/a	0	0.00%
	Amount (Php) of loans provided to CF cooperatives	0	166M	n/a	0	0.00%
	No. of CF cooperatives rated with good standing, or with past due accounts	0	0	n/a	0	0.00%

**Source: Implementation Progress Reports of CFITF IAs; **Source: CFIDP 2022-2026*

Inconsistencies on the provision of the CFITF Act and CFDIP, specifically the agency that implements the Health and Medical Program were realized by the implementing agencies along the program implementation. There is also a need to streamline the mandates of CDA, PhilMech, and DPWH under CFIDP, specifically on the establishment of coconut processing plants. In the Crop Insurance Program, it was proposed by the CFITF implementing agencies to fast-track the development of the Coconut Yield Insurance Product Package (CYIPP) as the currently approved package only covers coconut tree mortality. On the other hand, it was reiterated that the Scholarship Program shall prioritize agriculture-related programs or courses and called to reduce the required General Weighted Average (GWA) to serve and qualify more children of coconut farmers. Lastly, to give more opportunity for the coconut farmers and organizations to access credit, it was proposed to recalibrate the guidelines and terms sheets between PCA, DBP, and LBP.

***Outcome 1.1*. Sustained increase in coconut farmer's income and improved health of CF families with their access to nutritious dairy food**

With the intention to encourage coconut farmers to intercrop coffee/ cacao and venture into other business enterprises such as animal breeding and production, Outcome No. 1.1. aims to increase their income while improving their family members' health by providing them access to nutritious dairy food.

In the first year of implementation, only the distribution of farm inputs such as dairy animals, coffee, and cacao planting materials was undertaken by the CFITF implementing agencies under this component. At the end of the second year, delivery of services was again impeded due to policies and procedures in the procurement process of farm animals and other agricultural inputs.

Table 15. Component Outputs, Indicators, and Performance Targets of CFIDP Outcome 1.1

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
IV. COMMUNITY-BASED FARM IMPROVEMENT AND REHABILITATION						
DAIRY INTEGRATION (DA-NDA)						
Coconut-based Farming Systems/ Diversification -Dairy Integration	No. ha farms with coco-dairy farming	0	0	n/a	0	0.00%
	No. of CF Cooperatives with coco dairy farming	0	0	474	474	100.00 %
	No. of ha, of coconut farms integrated with dairy	0	0	1,615	1,615	100.00 %
	No. of liters of milk produced (000)	0	0	17	17	100.00 %

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
	No. of milk collection center established	0	0	43	43	100.00 %
	No. of milk processing plants established	0	0	24	24	100.00 %
	No. of dairy animals distributed	681	242	5,083	4,160	81.84%
	No. of animals insured	0	0	5,083	5,083	100.00 %
	No. of animals bred	0	0	11,792	11,792	100.00 %
	No. of animals provided with supplementation	28	921	6,942	5,993	86.33%
	Ha of forage developed	0	0	1,591	1,591	100.00 %
LIVESTOCK AND NATIVE ANIMALS INTEGRATION (DA-BAI)						
Coconut-based Farming Systems/ Native animal breeding and production	Annual HH Income of coconut farmers from dairy and native animal production	0	0	n/a	0	0.00%
	No. of CF engaged in integrated native animal breeding farming system	0	0	44,245	44,245	100.00 %
	No. of farmers benefited in native livestock and poultry modules	0	0	44,245	44,245	100.00 %

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
	Manukan sa niyugan	0	0	15,750	15,750	100.00%
	Babuyan sa niyugan	0	0	4,690	4,690	100.00%
	Kambingan sa niyugan	0	0	11,790	11,790	100.00%
	Bakahan sa niyugan	0	0	12,015	12,015	100.00%
	No. of native animals distributed	0	0	859,136	859,136	100.00%
INTERCROPPING OF COFFEE AND CACAO (DA-HVCDP)						
Coconut-Based Farming System- coffee and cacao production	No. of ha intercropped with coffee and cacao	0	1,120	12,700	11,580	91.18%
	Annual HH Income of coconut farmers from coffee and cacao production	0	0	n/a	0	0.00%
	No. of coffee planting materials distributed	78,682	143,080	2,504,400	2,282,638	91.15%
	No. of cacao planting materials distributed	307,624	371,069	3,797,551	3,118,858	82.13%
	No. of coffee trees rehabilitated	167,087	195,067	1,856,651	1,494,497	80.49%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
	No. of cacao trees rehabilitated	189,117	265,250	2,982,676	2,528,309	84.77%
Volume of production	Increase in coffee volume of production (mt)	0	0	6,405	6,405	100.00%
	Increase in cacao volume of production (mt)	0	0	7,838	7,838	100.00%
Area harvested (ha)	Increase in area harvested (coconut farms diversified), coffee	0	0	1,761	1,761	100.00%
	Increase in area harvested (coconut farms diversified), cacao	0	0	2,128	2,128	100.00%
Nursery Establishment	No. of sites	0	0	223	223	100.00%
Postharvest and processing facilities	No. of facilities	0	0	109	109	100.00%

**Source: Implementation Progress Reports of CFITF IAs; **Source: CFIDP 2022-2026*

As a way of ensuring that the trust fund will be utilized despite the challenges in the sources of farm inputs, the CFITF implementing agencies proposed steering measures and strategies which will be included in the proposed amendments to the CFIDP. This includes the provision of basic post-harvest and processing facilities/ equipment as a support to the intercropping of coffee and cacao and dairy integration. The clustering of farms was also recommended to increase from 50 to 100 hectares to expand the scope and further consolidate coconut farms. Finally, to address the program challenge in sourcing of native animals, a module for native horses was proposed as part of the native livestock and poultry integration.

***Outcome 2*: Improved productivity within ecological limit**

By promoting the adoption of innovative techniques and technologies, such as planting and replanting of coconut hybrids, the CFIDP seeks to boost yields without compromising the natural resources on which coconut farming depends. This commitment to sustainable productivity aligns with broader efforts to achieve agricultural resilience and food security, ultimately benefiting coconut farmers, the Philippine coconut industry, and the environment.

Despite the release of the trust fund allocation already in the third quarter of Year 1, PCA was able to facilitate the rollout of the Coconut Hybridization Program. There is a significant number of production of hybrid seedlings and mother palms, seedfarms, seedlings, and coconut area fertilized. This was even put to greater heights during Year 2 of implementation wherein accomplishments were doubled and more coconut farmers were reported to have benefitted from the various outputs under this component.

Meanwhile, for Years 1 and 2 of the component on research and development of coconut hybrids, the DOST-PCAARRD has been in close coordination with several research institutions to open more doors for research and development project funding. However, during the conduct of Public Consultations on the proposed amendments to the CFIDP there is a call to improve strategies in the transfer of technologies developed. Hence, to complement each important aspect of research and development, a review on the set indicators and strategies in place shall be done to address eminent gaps between the CFITF implementing agencies and the coconut farmers, especially on coconut hybrid R&D projects.

Table 16. Component Outputs, Indicators, and Performance Targets of CFIDP Outcome 2

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
V. COCONUT HYBRIDIZATION PROGRAM						
Operations (DA-PCA)						
Production of hybrid seedlings in the modernized/expanded PCA seed gardens	No. of seednuts produced	438,400	907,481	8,625,000	7,279,119	84.40%
	No. of mother palms hybridized	31,871	63,451	32,315	0	0.00%
	No. ha planted to hybrid and improved variety	0	0	n/a	0	0.00%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
On-farm hybridization with selected dwarfs and pollen from selected talls for planting materials	No. of seednuts produced	0	0	11,171,918	11,171,918	100.00%
	No. of mother palms hybridized	0	0	123,583	123,583	100.00%
	No. of hybrid coconut farms rented	0	0	n/a	0	0.00%
Established coconut seed farms and communal nurseries in government lands in partnership with LGUs and SUCs the long term.	No. ha of seedfarms established	26,880	636,982	403	0	0.00%
	No. of seedfarms	0	0	81	0	0.00%
	No. of seedling distributed planted	0	0	n/a	0	0.00%
	No. of communal nurseries	6	83	1,601	1,512	94.44%
	No. of seedlings raised	74,453	636,982	103,829,988	103,118,553	99.31%
Pollen Processing	Pollen processing facility established (No)	0	0	12	12	100.00%
	Male parental palms Tagged and Certified	0	0	60,909	60,909	100.00%
	Quantity of pollen produced	0	0	16,360	16,360	100.00%
	Quantity of pollen utilized	0	0	n/a	0	0.00%
Establish new coconut farms	No. of ha farms planted of hybrid	177	78	n/a	0	0.00%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
(hybrid & improved varieties)	(yield nuts/tree/year)					
Rehabilitation of coconut farms (replanting with hybrids and improved varieties)	No. of ha rehabilitated	0	0	103,830	103,830	100.00%
	No. of farmers benefited	0	0	103,830	103,830	100.00%
Nutrient Support for Existing Hybrids	Area fertilized (ha)	3,540	1,723	n/a	0	0.00%
Professionalization of coconut workforce through skills training in hybridization farms and creation of farm service crew teams.	No. of CFs trained	202	527	45,770	45,041	98.41%
	No. of teams of farm service crew	0	0	8,490	8,490	100.00%
Research and Development (DOST-PCAARRD)						
Developed hybrid coconut variety tested for yield and productivity	No. of hybridization research (new/completed/ongoing)	11	14	88	63	71.59%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
ready for mass propagation	No. of hybrids developed and approved for planting and replanting	0	0	n/a	0	0.00%
Technology transfer, promotion campaigns and IEC materials produced	No. of campaigns conducted and IEC materials produced and distributed	4	34	n/a	0	0.00%
	No. of coconut breeders and other researchers supported (trained/ advance degree)	0	0	n/a	0	0.00%

**Source: Implementation Progress Reports of CFITF IAs; **Source: CFIDP 2022-2026*

To improve its performance, the PCA proposes to include in the list of activities for funding the upgrading of its Seed Production and Research Centers, provision of irrigation systems in hybridization sites, the establishment of seedfarms in private and government lands, the inclusion of PCA-recommended coconut varieties for hybridization, among others. These will further support the delivery of quality services to coconut farmers with an aim to also be sustainable and widen the reach if the program.

<u>Outcome 3</u>: Increased support to coconut processing and value adding activities

No accomplished activities related to this outcome.

<u>Outcome 4</u>: Intensified rehabilitation and modernization of coconut industry

Through the CFITF Act, there is a significant push towards enhancing the support for coconut processing and value-adding activities, alongside intensified efforts in rehabilitating and modernizing the Philippine coconut industry. These initiatives aim to capitalize on the versatility and economic potential of coconuts, driving sustainable growth, and empowering coconut farmers and stakeholders.

The defined outputs and indicators under the implementation of the Shared Processing Facilities and Infrastructure Development Program cover both outcome numbers 3 and 4 for which activities encapsulated therein are interrelated and interdependent. For the first 2 years of program implementation, it can be observed that there is a need to review the indicators, recalibrate strategies, and formulate catch up measures to cover the hampered delivery of various programs, projects, and services under the mentioned national development programs. Thus, to address the evident gap in synchronized and strategic implementation, it was proposed by the CFITF implementing agencies to streamline the mandates along with the intention to revisit the performance targets of DA-PhilMech and DPWH.

Moreover, same with other CFIDP outcomes, there is a need to revisit the indicators as there is no set target in some line items which makes it difficult for the CFIDP PMO to monitor and provide recommendations.

Table 17. Component Outputs, Indicators, and Performance Targets of CFIDP Outcome Nos. 3 and 4

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
VI. SHARED PROCESSING FACILITIES (DA-PHILMECH)						
Established shared coconut processing facilities (SCPF) for CF cooperatives operation as an enterprise	No. of SCPFs completed by type/classification	0	44	945	901	95.34%
Established village level SCPF in operation (capacity building, technical training, O&M training, entrepreneurship training, etc.)	No. of SCPFs completed by type/classification turned over to CF cooperatives	0	44	945	901	95.34%
Establish integrated central processing system for multiple products with	No. of village level SCPF in operation as a business enterprise	0	0	n/a	0	0.00%
	Volume by type of products produced by the SCPF (output)	0	0	n/a	0	0.00%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
modern processing facilities and equipment	No. of coconut farmers using the services of the SCPF	0	26,361	157,660	131,299	83.28%
	Volume (in kgs) of coconut products (copra, white meat etc.) processed in the SCPFs (input)	0	0	n/a	0	0.00%
VII. INFRASTRUCTURE DEVELOPMENT (DPWH)						
Infrastructure support to coconut processing and value adding activities:	No. of CF cooperatives provided with support infrastructure	0	0	n/a	0	0.00%
Transport link to farms and buildings and utilities for the shared coconut processing facilities	No. of CF using the support infrastructures (roads and buildings)	0	0	n/a	0	0.00%
	No. kms of FMR roads completed	0	14.8	n/a	0	0.00%
	No. of buildings/utilities for shared facilities	0	0	n/a	0	0.00%
	No. of buildings for trading posts, area in sq.m.	0	0	n/a	0	0.00%
	No. of buildings for training centers (+sq.m.)	0	0	n/a	0	0.00%

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
	No. of fertigation facilities (+sq.m.)	0	0	n/a	0	0.00%
	No. of bridges, spillway type	0	0	n/a	0	0.00%
	No. of processing buildings (+sq.m.)	0	0	n/a	0	0.00%

**Source: Implementation Progress Reports of CFITF IAs; **Source: CFIDP 2022-2026*

***Outcome 5**: Expanded market access of coconut farmer organizations and Micro, Small, and Medium Enterprises (MSMEs)*

The CFIDP is poised to revolutionize market access for coconut farmer organizations and Micro, Small, and Medium Enterprises (MSMEs). With a strategic focus on enhancing competitiveness and sustainability, CFIDP aims to facilitate the integration of these entities into higher-value markets both domestically and internationally. Through targeted interventions such as capacity building, access to finance, technology adoption, and value chain integration, the CFIDP seeks to empower coconut farmer organizations and MSMEs, unlocking their potential to drive economic growth and foster inclusive development in the Philippine coconut sector.

Despite the notable amount of sales generated through the provision of marketing support for the coconut farmers in Years 1 and 2, it can be observed that there is a challenge in measuring and documenting the progress of accomplishments under this component. This is due to the absence of figures as to the performance targets of each indicator. Thus, there is a need to restate, review, and revisit respective indicators at the output and outcome levels to properly account for progress with clear descriptions, defined strategies, and intervention packages.

Table 18. Component Outputs, Indicators, and Performance Targets of CFIDP Outcome 5

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS*		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
VIII. RESEARCH, MARKETING, AND PROMOTIONS (DTI-BSMED)						

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS *		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
Conduct of market / industry research for high-value coconut products	No. of research for high value coconut products conducted	8	36	n/a	0	0.00 %
Develop export promotion programs for high-value coconut products	No. of export promotion program for high-value coconut products developed	0	0	n/a	0	0.00 %
	No. of high-value coconut products promoted and exported	0	0	n/a	0	0.00 %
	No. of exporters provided access and exposure to new or traditional markets	157	0	n/a	0	0.00 %
	No. of business matches arranged for producers of high-value coconut products	1374		n/a	0	0.00 %
	No. of companies with increased export performance/revenue generation	309	10	n/a	0	0.00 %
Provide export marketing	No. of export marketing activities for high-value coconut products conducted	8	1	n/a	0	0.00 %

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS *		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
assistance for high-value coconut products	No. of new exporters capacitated with market entry and product quality requirements	72	226	n/a	0	0.00 %
	No. of coconut farmers capacitated with market entry and product quality requirements	0	5,452	n/a	0	0.00 %
Develop market certifications policy advocacy for the coconut industry	No. of policy studies developed (with recommendations discussed with DA, PCA and DTI)	3	7	n/a	0	0.00 %
Promote investments in the coconut industry	No. of IEC and investment promotion materials developed	34	0	n/a	0	0.00 %
	No. of market matching activities conducted	0	24	n/a	0	0.00 %
	No. of supply contracts facilitated	3	0	n/a	0	0.00 %
Provide marketing support for the coconut industry	No. of trade fairs and Bagsakan events showcasing coconut-based products conducted	88	63	n/a	0	0.00 %

COMPONENT OUTPUTS	INDICATOR**	ACCOMPLISHMENTS *		5-YEAR TARGET	FOR IMPLEMENTATION	%
		2022	2023			
	No. of permanent stores with special settings of coconut-based products established	0	0	n/a	0	0.00 %
	Amount of sales generated	84,730,000.00	25,307,268,755.00	n/a	0	0.00 %
	No. of promotional materials on MSMEs with coconut-based products developed	0		n/a	0	0.00 %
	No. of MSMEs with coconut-based products onboarded to e-commerce platforms	8462	397	n/a	0	0.00 %

**Source: Implementation Progress Reports of CFITF IAs; **Source: CFIDP 2022-2026*

Utilization of the Coco Levy Trust Fund

Financial Performance

As stipulated in RA No. 11524, the government will consolidate its social investments in improving the socio-economic status of Filipino coconut farmers and reinvigorating the Philippine coconut industry through the provision of various programs, projects, and services under CFIDP. To roll out and operationalize it, the CFIDP provided guidance on the utilization of the Coco Levy Fund for the next five (5) years, consistent with Section 4 of RA No. 11524 that specifically sets forth the annual percentage allocation of the fifteen (15) identified implementing agencies.

Financial allocations in each intervention were duly identified by the implementing agencies led by the PCA, complementing it with the needs and potentials of the industry and the coconut farmers. Of the Php75 billion total allocation for the implementation of the CFITF Act, Php33 billion will be utilized for various interventions for coconut farmers from 2022 to 2026, parallel with the provisions in the approved CFIDP (*See Annex A for the detailed indicative annual allocation per Implementing Agency).*

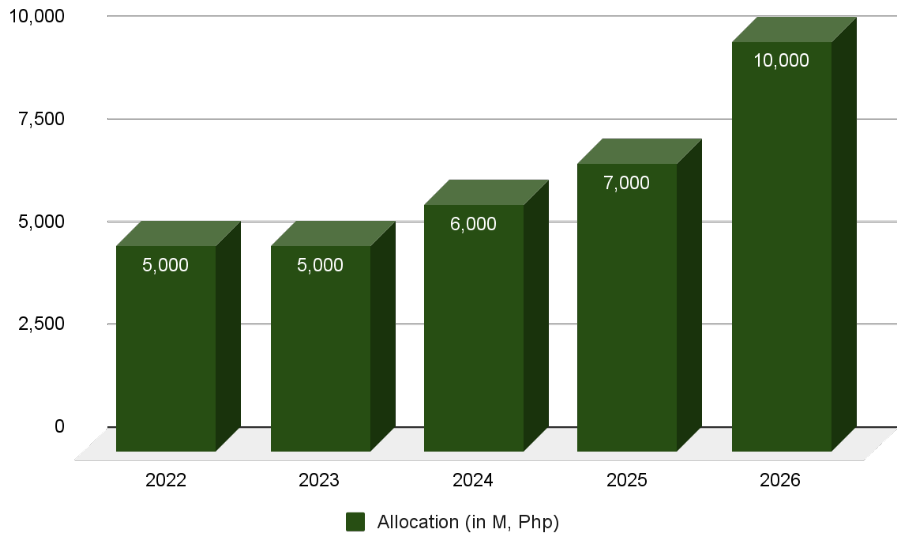


Figure 2. Indicative 5-Year Annual Financial Allocation for the Implementation of

National Development Programs under CFIDP[1]

For Year 1 (2022), implementation commenced in the third quarter, immediately after the approval of the CFIDP in June of the same year. Eight (8) implementing agencies were able to disburse 17.26% of the annual allocation with a total of Php863,112,124.60 from the Php5 billion budget for 2022. On the other hand, because of the harmonization efforts and intensified coordination among and between implementing agencies and the PCA, there was a notable increase in the utilization of the trust fund during the Year 2 implementation of the CFITF Act, totaling 47.52% disbursement or Php2,376,090,018.63 out of the Php5 billion allotment for 2023.

[1] Annual Indicative Investment Allocation. CFIDP 2022-2026, Chap. 7, p. 213

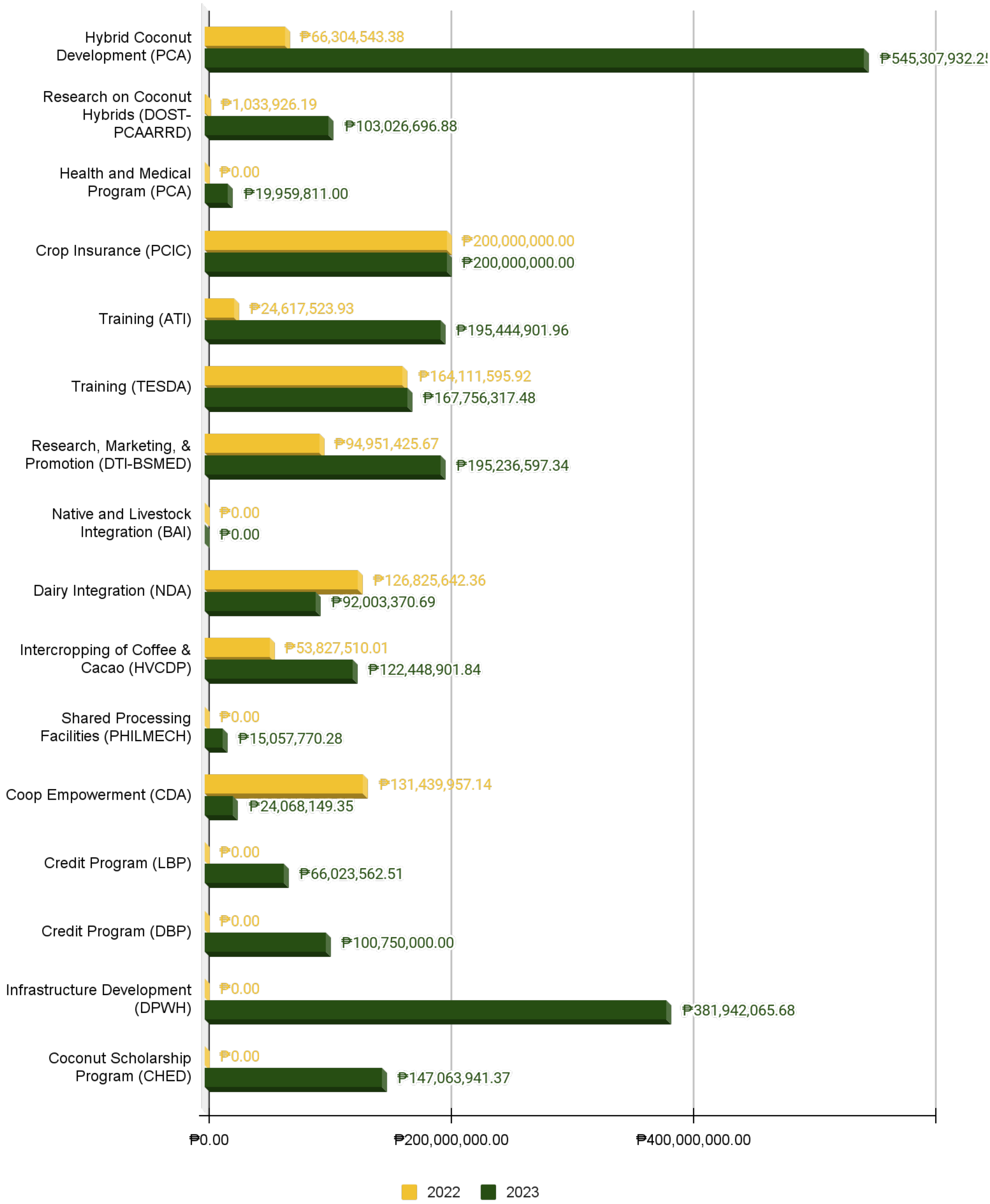


Figure 3. Annual Disbursement of CFITF Implementing Agencies in 2022 and 2023[2]

Based on the 5-Year allocation for the program implementation as stipulated in the CFIDP and RA No. 11524, it can be observed that there is a need for recalibrating steering

[2] Submitted Financial Utilization Report of CFITF Implementing Agencies (as of December 2022 and 2023)

measures, reviewing performance indicators, and ratifying policies to enhance the efficiency of service delivery and overall performance of the implementing agencies. This is because based on the Financial Utilization Reports (FURs) submitted by the CFITF implementing agencies to the Bureau of Treasury (BTr), only 9.82% of the Php33 billion for the 5-Year program implementation was utilized in Years 1 and 2 with a total of Php 3,239,202,143.23.

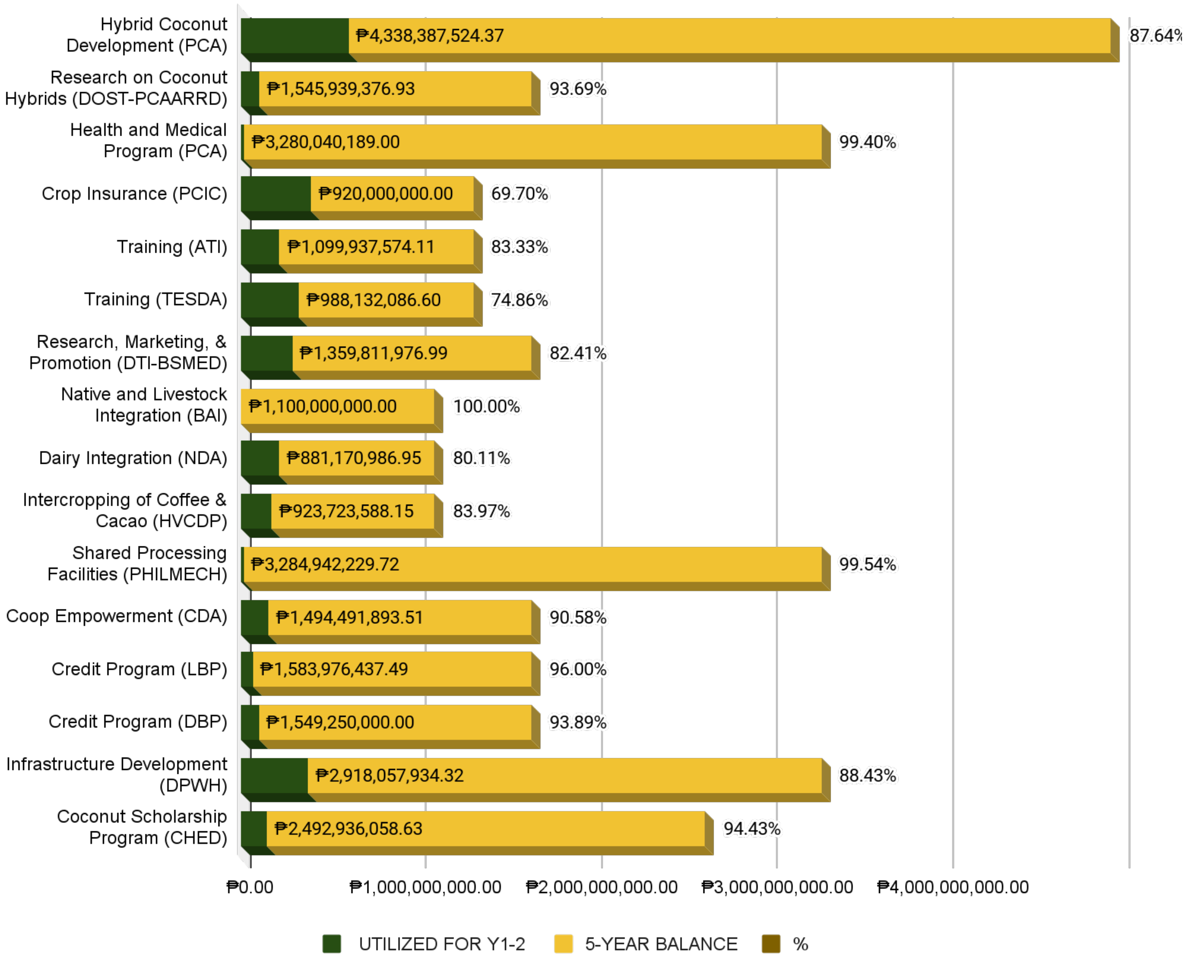


Figure 4. Remaining / Unutilized Trust Fund in the Php 33 Billion 5-Year Annual Allocation

Despite the significant increase in Year 2, the trust fund utilization is still low based on the CFIDP whereas 30.30% of the 5-Year allocation should already be utilized by the CFITF implementing agencies at the end of 2023. The financial report also implies that out of the total Php 75 billion allocated for the 50-year implementation of RA No. 11524, only 4.32% has been utilized for the Year 1 and Year 2 implementation. *(See Annex B for the detailed Financial Performance of the Implementing Agencies).*

The data presented above underscores the importance of reassessing the strategies and mechanisms in place to ensure the effective deployment of funds and the achievement of program objectives. Recalibrating steering measures may involve reevaluating the criteria for fund disbursement, enhancing monitoring and evaluation frameworks, and strengthening coordination among CFITF implementing agencies. Reviewing performance indicators can also help in setting realistic targets and benchmarks for assessing the overall impact of the CFITF Act on the Philippine coconut industry and the welfare of Filipino coconut farmers.

Additionally, ratifying policies to address bottlenecks and streamline processes can contribute to improving the efficiency and effectiveness of the CFITF Act implementation. This may include revising guidelines for project proposals, simplifying approval procedures, and enhancing transparency in fund allocation and utilization.

The significant underutilization of funds in Years 1 and 2 of the CFITF Act implementation calls for urgent measures to optimize the impact of the allocated resources. Nevertheless, while there have been challenges in fund utilization, efforts are underway to enhance the efficiency and effectiveness of the Coco Levy trust fund operations. The future looks promising, with significant allocations planned to further support Filipino coconut farmers and the Philippine coconut industry.

RECOMMENDATIONS

Looking ahead to 2024, the PCA is committed not only to enhancing fund utilization but also to fully operationalizing all CFIDP programs, ensuring that no program is left behind. Through previous discussions, it has been noted that certain implementing agencies (IAs) such as PCA-H&M, CDA, PhilMech, and DPWH faced challenges in implementation due to conflicts between mandates outlined in the law and the approved CFIDP. Consequently, the PCA has taken the initiative to craft amendments to the Plan, allowing these IAs greater flexibility for the benefit of the coconut farmers and their families. Presented below is the strategic plan to attain the CFIDP goals through the amendment of the Plan.

STRATEGIC ACTION PLAN: AMENDMENT OF CFIDP

GOAL 1: Align the CFIDP with the provisions of the RA No. 11524 & EO No. 172.

Objectives/ Targets	Strategies/ Activities	Time Frame	Office Involved	Expected Output/ Outcome	Remarks
Improve strategies and harmonize interventions under CFIDP through the conduct of one (1) annual meeting	Conduct FY 2023 Assessment and FY 2024 Planning Workshop	October 2023	Led by PCA with the involvement of CFIDP implementing Agencies (national) and in consultation with the Coconut Farmer Directors and regional oversight committees.	Policy Recommendations	Conducted on October 2-4, 2023
Complement the CFIDP with the current landscape of the industry through ratification of policy recommendations.	1. Preparation of proposed amendments to the CFIDP 2. Convene the Program Steering Committee to ratify the proposed amendments to CFIDP 3. Conduct Public Consultations	Oct-Nov 2023 December 5, 2023 March 2024	Led by PCA in consultation with National/ Regional Inter-Agency Technical Committees (N/RIATCs), TFMC, and CFITF Act Implementing Agencies	Resolution endorsing the Proposed CFIDP (amended version) to the Vetting Agencies	Conducted in January to March 2024
Facilitate the social investment under CFITF through the ratification of amended CFIDP	1. Coordination with CFIDP Vetting Agencies to solicit concurrence on proposed amendments to CFIDP 2. Approval of PCA Board and endorsement to the Office of the Philippine President	April 2024 May 2024	Led by PCA in coordination with the PCA Board and CFIDP vetting agencies such as NEDA, DTI, DBM, and DOF	Resolution endorsing the Proposed CFIDP (amended version) to the Office of the Philippine President	PCA has already informed the VAs about the intention to amend the CFIDP.

GOAL 2: Fully utilize the Trust Fund to improve the coconut industry and uplift the lives of the coconut farmers.

Objectives/ Targets	Strategies/ Activities	Time Frame	Office Involved	Expected Output/ Outcome	Remarks
Facilitate cascading of amended CFIDP through conduct of numerous information dissemination activities	Intensified information dissemination and use of communication platforms	2nd Sem 2024	Led by PCA with the involvement of CFIDP implementing Agencies (national/ regional) and in coordination with the Coconut Farmer Directors and regional oversight committees.	Well-informed coconut farmers, public, local government units, and other relevant stakeholders	PCA has included in its proposed PPAs the conduct of advocacy activities and intensified information drive
Ensure effective and efficient utilization of the Trust Fund through proper program management and coordination	Conduct of regular coordination meetings with implementing agencies and relevant stakeholders (N/RIATCs meetings) Conduct of Midyear Impact Evaluation	2024 (whole year)	PCA in coordination with Trust Fund Management Committee PCA and DA	Timely delivery of programs, projects, and services High utilization rate Impact Evaluation Results	PCA has already consolidated the Workplans of the implementing agencies Ongoing development of IIMS
Improve strategies and harmonize interventions under CFIDP through the conduct of one (1) annual meeting	Conduct FY 2024 Assessment and FY 2025 Planning Workshop	October 2024	Led by PCA with the involvement of CFIDP implementing Agencies (national) and in consultation with the Coconut Farmer Directors and regional oversight committees	Policy Recommendations	PCA has included in its proposed PPAs the conduct of Annual Program Review

Furthermore, the Trust Fund Management Committee has responded to the concerns of the IAs on lack of mobilization resources by providing them administrative funds for the purpose of implementing the CFIDP programs. Under TFMC Resolution 2023 – 011, the 2024 disbursement allocation has been increased from Php5 billion to Php7.5 billion, primarily to enable the Philippine Coconut Authority to cover administrative expenses of the implementing agencies related to the implementation of RA 11524. As such, the PCA will allocate 5% of the total fund to each implementing agency to cover these administrative expenses associated with CFIDP implementation.

To enhance PCA's monitoring of the overall CFIDP implementation, an integrated information management system will be developed and launched this year. This system aims to increase efficiency in monitoring program physical accomplishments and financial utilization. It will provide access to frontline information systems and live updates on program status and progress, enabling timely actions and recommendations by the PMO. The information system is designed to be user-friendly for field personnel and will be accessible via mobile applications. Program modules are strategically scheduled, with functionality expected to begin in June 2024 and extend through 2025.

Finally, the PCA aims to fully realize convergence among CFIDP programs by establishing model projects that will significantly contribute to industry development. These projects will target sites based on criteria such as the number of NCFRS-registered coconut farmers, poverty incidence levels, coconut production, infrastructure availability and accessibility, and community participation.

By adopting a collaborative strategy and harmonizing implementation efforts, the Philippine coconut industry can be propelled to greater heights. Programs, projects, and activities will enable implementing agencies to synergize and pool resources according to sector potentials, market demand/trends, and the needs of coconut farmers and their families.

With these approaches in place, the PCA is dedicated to proactive measures and enhancing the coordination among CFIDP programs. All IAs will advance with a heightened advantage compared to the preceding two years. It's recognized that our combined endeavors will culminate in achieving the paramount objective of the CFIDP – enhancing the lives and livelihoods of coconut farmers and their families, alongside the advancement and modernization of the coconut industry.

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ACKNOWLEDGMENTS

This is to extend our sincere gratitude to all individuals who have made valuable contributions towards the successful culmination of this study. The successful completion of this research project was made possible due to the essential support and assistance provided by the Philippine Coconut Authority particularly the Program Management Office and the Implementing Agencies provided under the Coconut Farmers and Industry Trust Fund Act.

VIRULENCE TESTING AND DETECTION OF GENETIC VARIATION PATTERNS USING SSR MARKERS IN GEOGRAPHIC ISOLATES OF *Metarhizium anisopliae* (METCHNIKOFF) SOROKIN COLLECTED FROM *Oryctes rhinoceros* (L.) AND *Brontispa longissima* (GESTRO)

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Abstract

This study assessed the virulence and genetic variation of Metarhizium anisopliae isolates collected from Oryctes rhinoceros, Brontispa longissima, and soil samples using 20 SSR markers. These markers identified 21 polymorphic loci among 36 GMF isolates, revealing 78 alleles with an average of 3.71 alleles per locus. Observed and expected heterozygosity were 0.378 and 0.507, respectively, indicating significant genetic diversity within and among host-derived samples. AMOVA results showed 69% variability within hosts and 31% among hosts. Cluster analysis suggested differentiation of isolates based on source hosts rather than geographical origin, with CLB-derived isolates forming a tight cluster, CRB-derived isolates distributing into four clusters, and soil-derived isolates forming a distinct cluster. Virulence tests demonstrated high effectiveness of GMF isolates against coconut rhinoceros beetle, with peak mortality at 7-11 days and an average mortality rate of 92.2% at 14 days post-application. Controls showed 100% larval survival. GMF isolates were also effective against the coconut leaf beetle, though with lower average mortality of 81.7% and a control mortality rate of 13.3%. These findings underscore the potential of GMF isolates in biological control, highlighting their genetic diversity and virulence against both beetle species.

Keywords – *Metarhizium anisopliae, Oryctes rhinoceros, Brontispa longissimi, AMOVA, and virulence testing.*

INTRODUCTION

Management of pests and diseases is a major component of good agrosystems practices. The infestation of the major insect pests—the coconut rhinoceros beetle (CRB) and leaf-defoliating coconut leaf beetle (CLB), contributes to significant yield loss in coconut. Palms with more than 40% defoliation caused by rhinoceros beetle feeding reduces nut retention and consequently, the nuts harvested. Prolonged attacks of coconut leaf beetle on the younger leaves of the palm result in stunting and reduced nut production, ultimately leading to death in young palms.

Efforts are in place to develop biological control as focal point in coconut integrated pest management (IPM) since most cultural and chemical pest control methods are either impractical or insufficient to manage coconut pests. The Green Muscardine Fungus (GMF) or Metarhizium anisopliae is one of the most utilized entomopathogens against CRB and CLB infestations. It is the first mass produced entomopathogenic fungi to control seven (7) different orders of insects (Tiago et al., 2014) and presently can be processed in a form that can be readily applied by famers). Mass production satellite laboratories were established and the fungus distributed to places where beetle infestation is high. However, some strains of this entomopathogen have variable virulence against the pests. In recent years, a new haplotype of CRB observed to be resistant to the GMF from the Philippines has been identified in Guam (Jackson and Marshall, 2017).

Characterization of the genetic diversity of entomopathogens is important in determining virulent strains to enable crop protection practitioners in identifying isolates that are appropriate to levels/magnitude of infestation. Moreover, genetic diversity analysis could give information on their specificity and pathogenicity leading to more rapid selection of useful isolates. Elucidation of the genetic variation patterns of GMF and its virulence will improve the deployment strategies of this biological control agent. In this study, 36 GMF isolates collected from different localities in the Philippines (Albay, Davao, Camarines Norte, Sorsogon, South Cotabato, Leyte, Southern Leyte, Eastern Samar) were used purified at PCA-ARC and PCA-DRC. The 36 isolates were characterized using twenty microsatellite (SSR) markers and 33 were used in virulence tests against CRB and CLB.

In their study, Brown, Smith, and Jones (2019) discovered a substantial amount of genetic variety among isolates from Oryctes rhinoceros. They found that this variability was associated with different levels of virulence. Chen, Wang, and Li (2020) discovered a significant amount of genetic variation in the isolates from *Brontispa longissima*. This highlights the crucial role of genetic determinants in determining the pathogenic capabilities of these fungal isolates.

Gómez, Pérez, and González (2021) and Henderson, Zhang, and Lee (2021) conducted additional studies that emphasized the geographical variation of Metarhizium anisopliae. These research employed SSR markers to discern discrete genetic clusters associated with certain areas. They noticed that samples from particular areas displayed greater virulence, indicating adaptation to the region and the possibility of choosing localized strains to improve the effectiveness of biocontrol.

Ishikawa, Tanaka, and Yamada (2022) and Johnson, Thompson, and Davis (2022) conducted research on the genetic differentiation and pathogenicity of Metarhizium anisopliae isolates. They discovered that the genetic profiles had a substantial impact on the ability of the isolates to cause disease. Their research emphasized the crucial need of genetic screening in the development of efficient biocontrol agents, as specific genetic characteristics were found to be linked to increased pathogenicity.

Kim, Park, and Choi (2023), Li, Huang, and Yang (2023), and Oliveira, Silva, and Martins (2024) conducted recent research that further supported these findings. Their studies utilized SSR markers to reveal significant genetic variation. The investigations shown that the genetic variety of the isolates was directly related to their virulence profiles, thereby advocating for the utilization of genetically diverse strains to enhance the efficacy of biocontrol applications. In their study, Wang, Liu, and Chen (2024) highlighted the importance of genetic profiling, demonstrating that variations in genetic makeup among isolates were linked to variations in virulence. This finding is essential for enhancing the effectiveness of biological control methods against insect pests.

Research Objective

This research aimed to assess the virulence and identify genetic variation patterns in geographic isolates of *Metarhizium anisopliae* (Metchnikoff) Sorokin. The research utilized simple sequence repeat (SSR) markers and collected samples from the insect hosts *Oryctes rhinoceros* (L.) and *Brontispa longissima* (Gestro). The work had two main objectives: to measure the harmfulness of several M. anisopliae isolates using controlled bioassays, and to identify polymorphic SSR markers that could indicate genetic diversity and population structure among the isolates from different geographic areas. The purpose of the study was to offer insights into the correlation between genetic variation and virulence in M. anisopliae, with potential implications for the biological management of *O. rhinoceros* and *B. longissima*.

Scope and Delimitation

This research focused on examining the virulence and detecting genetic variation patterns in geographic isolates of *Metarhizium anisopliae* taken from *Oryctes rhinoceros* and *Brontispa longissima*. Simple Sequence Repeat (SSR) markers were used for this purpose. This study focused on isolates collected from different geographical regions in order to evaluate the influence of environmental factors on both genetic diversity and pathogenicity. The study's delimitations encompassed the utilization of only SSR markers for genetic analysis, concentrating solely on isolates from *O. rhinoceros* and *B. longissima*. Additionally, virulence assays were conducted under controlled laboratory conditions rather than field conditions, potentially impacting the practical applicability of the findings.

Significance of the Study

This study would have been advantageous for agricultural scientists, entomologists, and biocontrol practitioners. The research conducted an analysis of the virulence and genetic diversity of *M. anisopliae* isolates from various pests, which yielded important insights into the efficacy and adaptation of biocontrol agents against these major agricultural pests. This knowledge could have proved beneficial for the development of more precise and efficient biocontrol techniques, ultimately assisting in the sustainable management of pests and decreasing dependence on chemical pesticides. Furthermore, the results would have provided valuable support for additional scholarly investigations and policy development focused on enhancing biocontrol methods in different geographic areas.

METHODS AND PROCEDURE

The study utilized a quantitative approach to evaluate the severity of disease and identify genetic differences in distinct populations of *Metarhizium anisopliae* obtained from *Oryctes rhinoceros* and *Brontispa longissima*. Virulence testing was performed through the use of standardized bioassays, in which insect hosts were subjected to varying quantities of fungal spores. The resulting mortality rates were then observed and recorded over a span of 14 days. The genetic variation among the isolates was assessed by using Simple Sequence Repeat (SSR) markers. Fungal cultures were used to extract DNA, which was subsequently amplified using polymerase chain reaction (PCR). Gel electrophoresis was performed to analyze the banding patterns of SSR. The data underwent statistical analysis to establish the linkage between levels of virulence and genetic diversity, enabling the identification of distinct genetic markers linked to strains with high virulence. This method yielded a thorough comprehension of the genetic composition and disease-causing capability of *M. anisopliae* populations in various geographical areas. In this study, 36 GMF isolates collected from different localities in the Philippines (Albay, Davao, Camarines Norte, Sorsogon, South Cotabato, Leyte, Southern Leyte, and Eastern Samar) were used purified at PCA-ARC and PCA-DRC. The 36 isolates were characterized using twenty microsatellite (SSR) markers and 33 were used in virulence tests against CRB and CLB.

RESULTS AND DISCUSSION

Characterization of GMF isolates using SSR markers

The 20 SSR markers detected a total of 21 loci and were all polymorphic for the 36 GMF isolates. Genetic diversity analysis revealed a total of 78 alleles at an average of 3.71 alleles per locus with 0.378 observed heterozygosity, and 0.507 expected heterozygosity. These results indicate genetic variation among and within the CRB-, CLB-, and soil-derived samples substantiated by the analysis of molecular variance (AMOVA) showing 69% within host and 31% among host variability. Distance-based cluster analysis revealed the tendency of the isolates to be differentiated according to the source hosts (**Fig. 1**) and not to geographical origin. Except for one sample, the GMF isolates from CLB formed a tight cluster. GMF isolates from CRB were more differentiated and were distributed in four clusters. GMF samples collected from the soil also formed a distinct cluster.

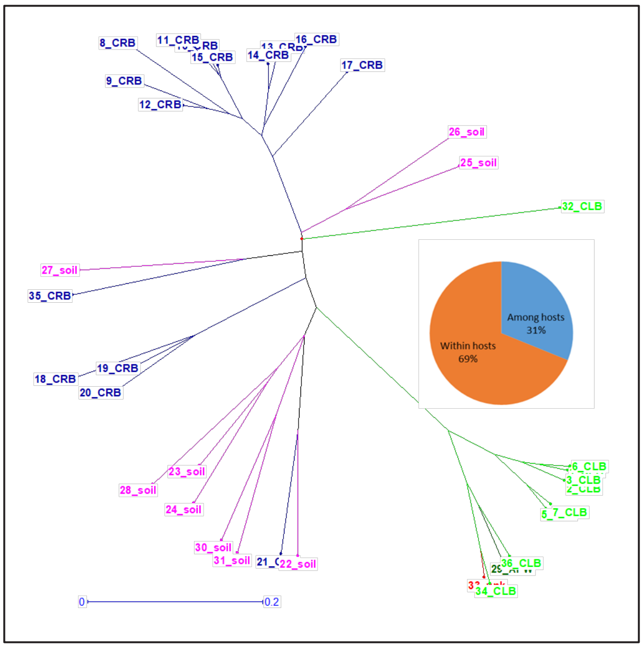

Fig. 1. *Unweighted neighbor joining tree of GMF populations obtained from different hosts and geographic locations.*

(Note: GMF samples from the same hosts showed a tendency to form distinct clusters. AMOVA results reflect high within-host variability among the CRB-derived samples.)

Virulence tests showed that the GMF isolates, regardless of the source and geographic origin, were effective against the coconut rhinoceros beetle. Mortality generally peaked at 7-11 days with a mean of 92.2% at 14 days after GMF application (**Fig. 2**). Mortality is attributed to the action of GMF isolates because 100% larval survival was recorded in the controls.

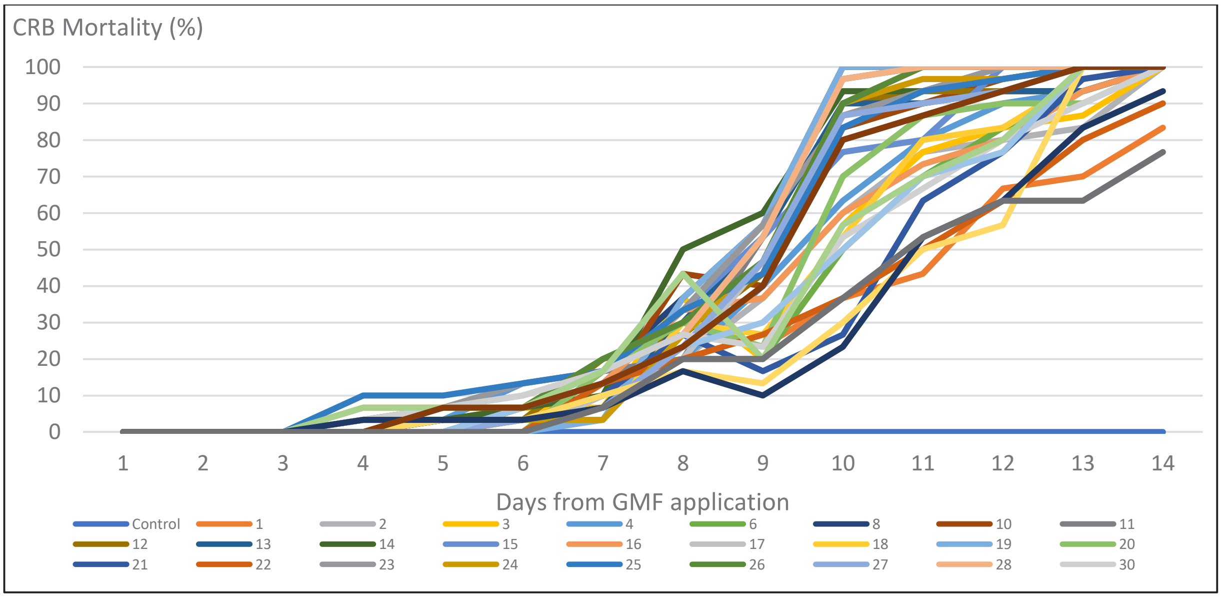

Fig. 2. *Mortality of CRB 3rd instar larvae with application of 33 GMF isolates. No mortality was recorded in the control.*

GMF derived from CRB, CLB and soil all proved to be effective against CLB. Virulence test against the coconut leaf beetle showed comparable trends as CRB, although a low level of mortality (13.3%) was observed in the CLB control set-up and the average CLB mortality at 14 days after GMF application was lower at 81.7%.

CONCLUSION

The genetic variation patterns detected in the study show a tendency for host-dependent clusters but with within- and among- hosts variation that might explain the efficacy of the isolates against both CRB and CLB. These results support broad application of the entomopathogen regardless of the host source or geographic origin of the GMF isolates.

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Micropropagation of coconut at PCA-Albay Research Center

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Abstract

The Philippine Coconut Authority-Albay Research Center (PCA-ARC) continues research on vegetative propagation of coconut planting materials. For more than three (3) decades, inflorescence tissues are being used as explants to clone the coconuts. Leaf explants were used in 2015-2020 but was discontinued due to difficulty in collecting the responsive leaf without killing the mother palm. Research on ovary culture started from 2016 onwards. Improvement of culture conditions anticipating regeneration of true-to-type planting materials aimed to supplement the coconut embryo culture and seednut germination. Calloid formation has been suceeded using Eeuwens (Y3, 1976) as the basal culture medium supplemented with different 2,4-D levels for the culture of the above three (3) somatic tissues. The addition of 2iP during calloid formation and BAP during calloid maturation is better for the culture of inflorescence tissues. TDZ or BAP was found optimal for initial calloid formation from leaves while TDZ only was optimal for ovary cultures. Calloids formation is evident 1.5 months (88%-100%) and 1 month onwards (3-11%) for inflorescence and ovaries, respectively. Optimization of culture media using various growth regulator combinations (2,4-D x BAP x GA3 x ABA) showed that transferring globular, transluscent calloids to media supplemented with 2,4-D + ABA with or without GA3 improved pre-somatic embryo (PSE) and somatic embryo (SE) production. Somatic embryo development and maturation were stimulated by transferring SE, PSE, and pearly, globular calloids to media with 2,4-D + GA3 with or without ABA. Inflorescence derived calloid in media with 2 ppm 2,4-D and 20 ppm BAP resulted in somatic embryo formation and maturation while cultures in media with 1.32 ppm 2,4-D, 67.5 ppm BAP, 1.59 ppm GA3 or 2.2 ppm 2,4-D, 1.8 ppm BAP turned haustorial, vitrified, and brown. Plantlet regeneration from ovary cultures is being achieved. Sixteen plantlets were attained from one leaf cabbage as the highest regeneration recorded. Twenty (20) inflorescence- and one (1) leaf-derived clones were successfully established in the field and nursery, respectively.

Keywords: *vegetative propagation, somatic embryo, pre-somatic embryo, plant regeneration*

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Paper presented during the 1st International Scientific Conference on Coconut Conservation, Valorization and Exchange of Resources and Germplasm for Economic Development of the Coconut Industry (I-CONVERGED), 27-30 November 2023, SEARCA, College, 4031, Los Baños, Laguna, Philippines.

Introduction

Coconut remains to be one of the important commodity crops in the Philippines as source of high-value food and non-food products, contributing greatly to the national economy. However, it was estimated that 31.5% of the 345.6 Million coconut palms in the country are aging or would be senile in the next 10 years (Philippine Statistics Authority, 2020). Thus, the country needs 112M planting materials for replanting of senile palms and 88M for expansion of coconut plantations to include planting along coastal areas (CFIDP, 2022). Rejuvenation of coconut plantations involve replanting of senile mother palms and those palms which are too high for hybridization purposes. In support to the Coconut Hybridization Project, the coconut tissue culture protocol is a potential complementary method to mass produce the coconuts. Clonal propagation using somatic tissues via somatic embryogenesis is an attractive option to propagate true-to-type planting materials of parental lines of PCA recommended varieties. It aims to complement seednut germination and embryo culture techniques of producing high quality coconut planting materials. The protocols for cloning the coconuts have been developed in various laboratories using somatic tissues such as inflorescence (Branton and Blake, 1983; Verdeil et al., 1994; Ebert et al., 1994a, 1994b, Cueto et al., 1997), leaf (Pannetier and Buffard-Morel, 1982; Gupta et al., 1984, Raju et al., 1984; Verdeil et al.,1989, 1992, 1994; Karunaratne et al., 1991; Buffard-Morel et al., 1992, 1995) and unfertilized ovaries (Karunaratne and Periyapperuma, 1989; Fernando, 2001; Perera et al., 2009; Vidhanaarachchi et al., 2013; Vidhanaarachchi, 2022). However, the use of these somatic tissues collected at PCA-Albay and cultured in the above published media produced variable degree of success or no response at all under our working conditions, hence, this study.

This research work was conducted at Philippine Coconut Authority-Albay Research Center, Banao, Guinobatan, Albay. The Province of Albay is one of the coconut-producing provinces in the Bicol Region, southern part of the Philippines. The objective of the study is to present the status of cloning the coconuts using immature inflorescence, non-chlorophyllous leaves and immature ovaries at PCA-Albay Research Center (PCA-ARC). The optimization of the different tissue culture protocols with emphasis but not limited to the growth medium is the main focus of the coconut tissue culture activities at PCA-ARC.

Materials and Methods

Immature Inflorescence

The use of immature inflorescence started in 1990s with funds from German Agency for Technical Cooperation (GTZ), followed by European Commission (EC) in 1996, Department of Science and Technology-Philippine Council for Agriculture and Aquatic Resources Research and Development (DOST-PCAARRD) in 1999, Australian Center for International Agricultural Research (ACIAR) in 2003, Department of Agriculture (DA)-Biotechnology Project Implementing Unit in 2007, and Philippine Coconut Authority (PCA) in 2011. The coconut tissue culture protocol with emphasis but not limited to nutrient formulation, growth regulators at different stages in culture for immature inflorescence were optimized under PCA-ARC working conditions and varieties (Laguna Tall, Aromatic Dwarf x Makapuno, San Isidro Dwarf). Immature inflorescence designated as inflorescence No. 4 which corresponded to frond No. 4 was collected from mature bearing palms using the non-lethal collection technique developed by Rillo (1989). The male flowers were cut into small pieces and cultured in Branton and Blake's (1983) nutrient formulation supplemented with varying levels (33-55 ppm) of 2,4-D for calloid formation. The 2,4-D level was increased from 10^{-4} ppm to 2×10^{-4} ppm to promote calloid multiplication. The initial cytokinin 2iP was replaced with BAP to induce maturation and germination of somatic embryos. The 2,4-D concentration was gradually reduced to 30 ppm and cytokinin level simultaneously increased up to 70 ppm to promote conversion of somatic embryos to plantlets. A demonstration plot was established at Philippine Coconut Authority-Albay Research Center, Banao, Guinobatan, Albay to showcase the use of coconut somatic embryogenesis-derived coconuts.

Immature Leaves

The use of non-chlorophyllous leaves started in 1990s funded by the German Agency for Technical Cooperation (GTZ). From 1990-1996, non-chlorophyllous leaves excised from nursery seedlings were used in the optimization of disinfection technique and growth medium. Ideally, explants for cloning the coconuts should come from bearing palms, thus, succeeding studies to optimize requirements for the successful establishment of leaf cultures resumed in 2015-2020 with funds from Philippine Coconut Authority under the Coconut Research and Development Program (CRDP). The method of collecting the leaf cabbage as source of immature leaves was developed (Ubaldo and Cueto, 2016). Growth medium components such as nutrient formation and combination of growth regulators at various stages of development were optimized for the culture of non-chlorophyllous leaves from Laguna Tall. Leaves collected from 1- to 2-yo palms (approx. age after field planting) were cultured in modified Eeuwens (Y3) medium supplemented with 2,4-D (80 ppm), TDZ or BAP to induce calloid formation. Calloids were multiplied and matured in medium with 72 ppm and 52 ppm 2,4-D for calloid multiplication and maturation, respectively. The regeneration protocol developed for the culture of plumule tissues was used for leaf cultures.

Unfertilized Ovaries

Studies to optimize protocols for the culture of unfertilized ovaries started in 2016 with funds from Philippine Coconut Authority under the Coconut Research and Development Program (CRDP) and is on-going. The ideal source of immature ovaries, nutrient formulation and combination of growth regulators from calloid initiation and multiplication, somatic embryo formation and maturation were identified. Immature inflorescences from cultivars Malayan Yellow Dwarf (MYD), Catigan Dwarf (CATD) and Laguna Tall (LAGT) were used as sources of unfertilized ovaries. Unfertilized ovary tissues were excised from the inflorescences that opened approximately after four (4) and five (5) months (designated as Inflorescence Nos. -4 and -5, respectively) where the last opened inflorescence is designated as Inflorescence Number 0) (Perera et al., 2007, 2009). Ovary tissues were cultured in calloid induction medium with Y3 nutrient formulation supplemented with 2,4-D, TDZ, table grade sugar, and activated charcoal, solidified with Gelrite, pH adjusted to 5.8 (Ubaldo et al., 2020b). Globular calloids were subcultured in medium supplemented with different combinations of 2,4-D x BAP x ABA x GA3 to induce calloid maturation and somatic embryo formation and conversion.

Results

Immature Inflorescence

The culture of rachillae explants of immature inflorescence in Eeuwens (Y3, 1976) medium formulation supplemented with a range of 2,4-Dichlorophenoxyacetic acid (2,4-D) level and N^6-isopentyl adenine (2iP) induced calloid formation 1.5 months after initial culture. Calloid multiplication was enhanced in medium supplemented with 6-Benzylaminopurine (BAP) instead of 2iP. Somatic embryos formed on the 8th month when globular calloids were transferred in 2,4-D-supplemented Y3 medium either with BAP or ABA with or without gibberellic acid (GA3). Maturation of somatic embryos was obtained in medium with 2,4-D and BAP. Shootlet regeneration started on the 28th month onwards. Nineteen plantlets were attained from one inflorescence as the highest regeneration recorded (Cueto et al., 2011). To date, 20 inflorescence-derived palms cv. Laguna Tall (15), Aromatic Dwarf x Makapuno (AROD x MAKT) (4) and San Isidro Dwarf (SNID) (1) are being maintained in the field and at bearing stage.

Immature Leaves

The collection of leaf cabbage without killing the bearing palm was developed by cutting the base of frond with the use of a chisel and hammer (Ubaldo et al., 2016). Palms with more than 70% of the crown remaining showed continuous growth and developed new expanded leaves as early as 24 days after leaf cabbage was collected. The culture of non-chlorophyllous leaves in Y3 medium formulation supplemented with 2,4-D range and either Thidiazuron (TDZ) or BAP formed calloids on the 4th month. Calloid multiplication was induced in medium supplemented with BAP as cytokinin. Selection and subculture of globular calloids in 2,4-D-medium either with BAP or ABA and GA3 enhanced somatic embryo formation. Maturation of leaf-derived somatic embryos was induced in medium supplemented with 2,4-D and BAP. Conversion of somatic embryos to shootlet was observed on the 42nd month. The highest recorded regeneration efficiency from one leaf cabbage was 16 regenerants. The PCA-ARC's first clonal plantlet from leaf tissue cv. Laguna Tall is being maintained in the nursery until ready for field planting. Laguna Tall variety as source of immature leaves was found to be responsive to in vitro culture. However, due to difficulty in collecting responsive leaves without killing the mother palm, thus, further optimization of culture medium was discontinued.

Unfertilized Ovaries

Unfertilized ovary tissues excised from the inflorescence that opened approximately after four (4) and five (5) months (designated as Inflorescence Nos. -4 and -5, respectively) where the last opened inflorescence is designated as Inflorescence Number 0) (Perera et al., 2007, 2009). The culture of unfertilized ovaries in Y3 medium formulation supplemented with 2,4-D range and TDZ induced calloids on the 1st month. Routine selection and subculture in higher 2,4-D-medium with TDZ induced calloid multiplication. Somatic embryos formed after subculturing globular calloids in 2,4-D-supplemented medium with ABA, with or without GA3. Somatic embryo development and maturation were stimulated by transferring SE, PSE, and pearly, globular calloids to media with 2,4-D + GA3 with or without ABA. Somatic embryo germination was observed on the 5th month. Plantlet regeneration from ovary cultures is being achieved. Cultures are being maintained by subculturing in their respective treatment until plantlet regeneration.

Discussion

Successful results on coconut somatic embryogenesis was obtained from the culture of immature inflorescence, non-chlorophyllous leaves and unfertilized ovary tissues in Eeuwens (Y3, 1976) medium formulation. Calloid production in coconut tissue culture is very much dependent on auxin, specifically, 2,4-D. Because of the varying levels of success as influenced by the genotype, successful callogenesis from the three (3) somatic tissues was attained by initially culturing onto a range of 2,4-D concentrations (Cueto et al., 2011; Ubaldo et al, 2020a, 2020b). Cytokinin was found essential during calloid initiation, however the response of the three (3) somatic tissues depended on the cytokinin used. N^6-isopentyl adenine (2-iP) was among the cytokinins that gave low browning incidence during initial establishment of inflorescence cultures (Ebert, 1992; Ebert et al., 1994a, 1994b; Rillo et al., 2008). TDZ produced significant results from ovary cultures (Satharasinghe et al., 2013). Earlier findings under the PCA-CRDP project showed that the combination of TDZ or BAP with 2,4-D in the calloid induction medium was favourable for leaf cultures (Ubaldo et al, 2020a). Formation of transluscent, shiny, white calloids was the initial type of calloids produced from the explants.

The amount of auxin 2,4-D plays an important role during callogenesis in coconut cultures. Maintenance of these initial calloids from the three (3) somatic tissues in calloid multiplication medium with increasing the 2,4-D concentration in addition to BAP increased supply of callus lines with embryogenic competence from immature inflorescence and leaves. The combination of 2,4-D with TDZ gave favourable results in terms of calloid multiplication from ovary cultures.

Regeneration medium with a combination of reduced level of auxin (2,4-D) and increased cytokinin (BAP) favored somatic embryo formation, maturation and regeneration as observed from coconut tissues such as inflorescence (Branton and Blake, 1983; Verdeil et al., 1994; Ebert et al., 1994a, 1994b; Cueto et al., 1997; Perez-Nuñez et al., 2006) and immature leaves (Ubaldo et al, 2020a). ABA and/ or GA3 enhanced somatic embryo formation from inflorescence and leaf cultures while SE formation and maturation from ovary cultures. Earlier reported favourable effects of ABA on the development of somatic embryos was obtained from the culture various coconut tissues such as inflorescence (Cueto et al., 2011) and plumule (Fernando and Gamage, 2000). Maturation of inflorescence-derived somatic embryos was promoted with the addition of 0.264-1.32 ppm ABA in the medium. However, embryo germination was only noted in the control treatment (without ABA) (Rillo et al., 2005). Successful results on somatic embryo formation was earlier reported from ovary-derived cultures in Y3 medium + BAP + AC and plantlet regeneration in Y3+ 2,4-D + BAP + GA3 + AC (Vidhanaarachchi, 2022; Vidhanaarachchi et al., 2013). Culture requirements for plantlet regeneration from ovary cultures are being studied.

Ex vitro Establishment of Tissue Culture-derived Plantlets

The ex vitro establishment protocol developed for coconut embryo culture works for the somatic embryogenesis-derived plantlets. Only plantlets with at least two (2) true leaves and profuse secondary root system successfully survived after potting out. Successful establishment of twenty (20) inflorescence- and one (1) leaf-derived clones in the field and nursery, respectively demonstrated the technical feasibility of mass propagating coconuts using tissue culture technique.

Conclusion

Immature inflorescences and unfertilized ovaries are promising explants for clonal propagation of coconut. 2,4-D is essential from calloid initiation up to somatic embryo maturation from the three (3) somatic tissues. Cytokinin requirement for calloid initiation varies among three (3) somatic tissues. Eeuwens (Y3, 1976) medium formulation supplemented with auxin (2,4-D) and cytokinin (BAP) induced calloid multiplication from inflorescence and leaf cultures, while combination of 2,4-D and TDZ was found favourable from ovary cultures. Generally, somatic embryo formation and maturation from the three (3) somatic tissues has been demonstrated in medium supplemented with 2,4-D and BAP. The addition of ABA and/or GA3 also enhanced somatic embryo formation. Culture requirements for plantlet regeneration from ovary cultures is being established. Twenty (20) inflorescence- and one (1) leaf-derived clones were successfully established in the field and nursery, respectively.

Acknowledgement

The authors wish to express our appreciation and gratitude to the German Agency for Technical Cooperation (GTZ), European Commission (EC), Department of Science and Technology-Philippine Council for Agriculture and Aquatic Resources Research and Development (DOST-PCAARRD), Australian Center for International Agricultural Research (ACIAR), Department of Agriculture (DA)-Biotechnology Project Implementing Unit, and Philippine Coconut Authority (PCA) for the financial support extended to the projects on coconut somatic embryogenesis. Thanks are due to Dr. Maria Elizabeth B. Naredo for her great contribution in the edition of this paper, to PCA Administrator and Research and Development Branch for the administrative support, PCA-ARC management and local administrative staff for the administrative support, PCA Region 5 Administrative staff and Tissue Culture support staff and all the others who helped in the realization of the objectives of the Project.

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Table 1. Duration in culture and other supplements to Y3 basal medium for inflorescence, leaf and ovary cultures

Explant	Calloid formation	Calloid Mutiplication	Somatic Embryo (SE) Formation	Somatic Embryo maturation	SE Germination and Shootlet formation
Inflorescence	1.5th month 2,4-D range + 2iP	2,4-D + BAP	8th month 2,4-D +BAP 2,4-D + ABA with or without GA3	2,4-D + BAP	28th month (shootlet) Regeneration efficiency: 1 Inflorescence : 19 regenerants
Leaf	4th month 2,4-D range + TDZ/BAP	2,4-D + BAP	20th month 2,4-D + BAP 2,4-D + ABA + GA3	2,4-D + BAP	42nd month (shootlet) Regeneration efficiency: 1 leaf cabbage : 16 regenerants
Ovary	1st month 2,4-D range + TDZ	2,4-D + TDZ	4th month 2,4-D + ABA + with or without GA3	2,4-D + GA_3 + with or without ABA	5th month (SE germination)

Figure 1. Inflorescence-derived tissues and plants: (a) immature inflorescence no. 4, (b) calloids, (c) somatic embryo, (d) shootlets, (e) plantlets in the nursery, and (f) inflorescence-derived palms at PCA-Albay Research Center.

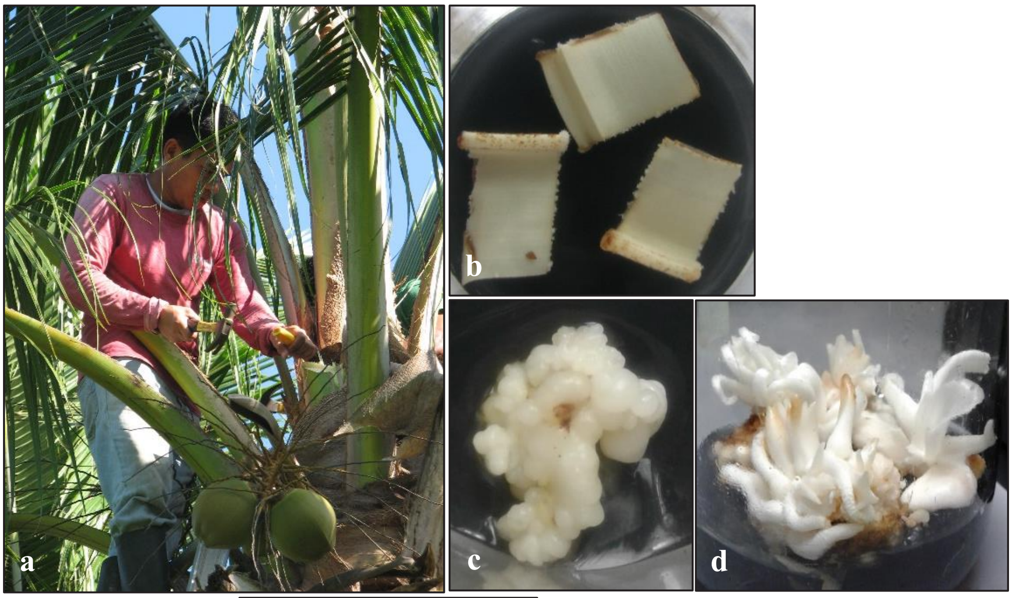

Figure 2. Leaf-derived tissues, cultures and plants: (a) collection of leaf cabbage without killing the mother palm, (b) non-chlorophyllous leaves, (c) calloids, (d) somatic embryos, (e) plantlet in the lab and (f) nursery.

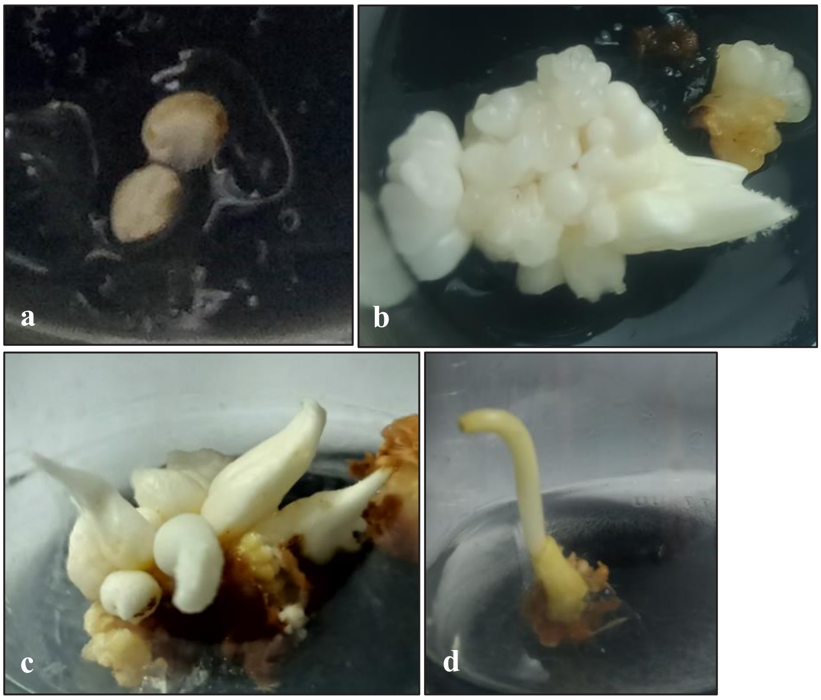

Figure 3. Ovary-derived cultures: (a) unfertilized ovary, (b) mixed embryogenic calloids and somatic embryo (c) somatic embryos, (d) germinating somatic embryo

INTEGRATED SOIL FERTILITY MANAGEMENT IN BEARING COCONUT AGROECOSYSTEMS IN THE PHILIPPINES: A RESEARCH NOTE

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Abstract

This research paper examined the effects of integrated soil fertility management strategies on coconut agroecosystems in the Philippines. The objective of the study was to improve productivity by using organic nitrogen-containing fertilizers in combination with potassium chloride (KCl) and chlorine-containing mineral fertilizers to solve deficits in nitrogen (N), potassium (K), and chlorine (Cl). The study's findings indicated substantial improvements in both nut and copra output yields. The yield improvements for nut production varied from 44.34% to 241.75%, while for copra per hectare per year, the improvements ranged from 51.50% to 227.92%. More precisely, when organic nitrogen-containing fertilizers were combined with chlorine-containing mineral fertilizers on soils that already had sufficient potassium, the yields of nuts increased by 89.88% to 279.53% and the yields of copra increased by 81.23% to 260.29%. Moreover, the integrated method decreased the overall need for fertilizer, emphasizing the efficiency improvements in resource utilization. The study's findings indicate that using successful fertilization procedures leads to substantial improvements in crop output, providing concrete benefits for coconut growers in the area.

Keywords – *Soil fertility management, coconut agroecosystems, organic nitrogen-containing fertilizers, nut production, and fertilization procedures.*

INTRODUCTION

Research and field observations in the country have shown that there are widespread deficits of soil nutrients, specifically nitrogen, potassium, phosphorus, chloride, sulfur, and micronutrients like boron and zinc. These deficiencies lead to imbalances in crop nutrition.

The most effective and feasible method to promptly enhance agricultural productivity is by addressing soil nutrient deficiencies through strategic application of fertilizers and implementing integrated soil fertility management, which involves combining mineral or inorganic fertilizers with organic or natural fertilizers over an extended period of time.

According to Magat (1993), there were clear signs of the necessity for integrated soil fertility management (ISFM) in agricultural output. This measure involves the application of the most effective combination of organic or natural fertilizers and mineral/chemical or inorganic sources on crops. It is expected to lead to modern and sustainable agriculture, which is practical, profitable, environmentally friendly, and improves the quality of life for all.

Consequently, there is a steady movement in research efforts from solely using mineral fertilizers to using organic fertilizers or a combination of both, in order to promote the idea of integrated soil fertility management (ISFM) in coconut farming. Optimal crop yields can be attained by combining organic soil amendments with mineral fertilizers.

METHODS AND PROCEDURE

Integrated soil fertility management (ISFM) in coconut farming involves the strategic use of both organic or natural and mineral or chemical fertilizers. The goal is to achieve the highest possible economic yield while maintaining a sustainable, cost-effective, environmentally friendly, and socially acceptable production system (Magat, 1991).

Optimal soil fertility management can be achieved by utilizing a combination of organic soil amendments and mineral fertilizers, which ensures a well-balanced supply of nutrients for crops. Organic soil amendments provide a more balanced supply of nutrients and release them at a slower rate when the organic matter decomposes. This allows for a longer time of nutrient availability to plants, resulting in increased crop yields and stability in yield. ISFM adopts the ideas of plant production ecology, which states that the yield of plants is determined by the interplay between genotype (genetic makeup), environment, and management practices.

The coconut sections of the country are found to have significant nutritional inadequacies in Nitrogen (N), Potassium (K), Chlorine (Cl), and Sulfur (S). This supports the findings of Ouvrier and Ochs (1979) that coconuts require high levels of these four nutrients.

RESULTS AND DISCUSSION

A. Use of Mineral fertilizers

Mineral fertilizers recommended for coconut containing nitrogen, potassium and chlorine are required to supplement the nutrients recycled or added in the form of crop residues and animal manures. Fertilizers are concentrated sources of essential elements in a form that is readily available to plant uptake. Farmers view them as most costly as they require a cash outlay.

B. Use of Organic Soil Amendments

ISFM emphasizes that importance of optimizing the use of organic resources after exploring their opportunity cost. Organic inputs such as biological nitrogen-fixers, crop residues and animal manure are an important source of nutrients. However, N, P, K, Mg and Ca content is only following decomposition. In addition to supplying nutrients organic inputs also contribute to crop growth in other ways by:

- Increasing crop response to mineral fertilizer.
- Improving the soil capacity to store moisture.
- Regulating soil chemical and physical properties that affect nutrient storage and availability.

- Adding nutrients not contained in mineral fertilizers.
- Creating a better rooting environment for root development.
- Replenishing organic matter.

C. Effects of Integrated Soil Fertility Management to Bearing Palms

Dramatic increases were noted in all fertilizer treatments (lower and higher levels of inorganic, organic alone and organic + Cl source) in terms of nut per palm, copra per nut and copra per palm per year. Long term organic fertilization improved organic matter, soil structure and base saturation (Canja et. al., 1996). There were also improvements in nut yield in either chicken dung applied singly or in combination with Cl over the control palms in Aklan and Samar.

A naturally occurring fertilizer material, i.e. chicken manure showed potential as N-source fertilizer, hence can be a good substitute for ammonium sulfate. Organic soil amendments (commercial or naturally- occurring ones) were in more effective when combined with Cl source. This observation clearly demonstrates the significant role of Cl macronutrient in coconut production (Secretaria, et al., 1995).

In the case of hybrid coconuts, a combination of organic and Cl (from inorganic fertilizers) gave higher yield in places like Zamboanga City, Dipolog City, Agusan del Sur, and South Cotabato, although their yields were lower than the pure inorganic fertilizer treatments (Margate et al., 1997; Secretaria et al., 1997; Secretaria et al., 1994). *Table 1* presents the organic and inorganic combination from the on-farm fertilizer trials (OFFT) conducted across the country.

Table 1. Organic Soil Amendments and Mineral Fertilizer Combination for Coconut Fertilization

Location	Recommended Rate
Region V- Sipocot, Camarines Sur	10 kg Chicken Dung + 1.5 kg KCl
Region V, Tabaco, Albay	10 kg Cow manure + 1.3 kg KCl
Region IV, Mauban, Quezon	12 kg Chicken Dung + 2.0 kg KCl
Region VII, Danao, Cebu	10 kg COF + 1.21 kg KCl
Region VIII- Lale, Western Samar	12 kg peat soil + 1.6 kg KCl
Region IX, Zamboanga City	10 kg Commercial Organic Fertilizer + 1.5 kg KCl
Region XII, Polonuling, South Cotabato	10 kg Corn cob + 1.8 kg NaCl

D. Recommended Organic Soil Amendments + Mineral Fertilizer Combinations

Tables 2 and 3 present the combination of organic soil amendments and mineral fertilizer for coconut at different growing stages. Fertilizer combination ranged from 80-83% for organic soil amendments and 17-20% for mineral fertilizer. The combination of organic soil amendments and mineral fertilizers depends on the range of the sufficiency of the available form of K in the soil.

Roba (2018) concluded that soil fertility and productivity can be improved and reduce the impact of inorganic fertilizer on environment by combined application of organic and inorganic fertilizers. Thus, it is an alternative way for sustainable soil fertility and productivity.

According to Ali, et. al., (2009) combined use of organic and inorganic fertilizers plays a significant role in sustaining soil fertility. The combine application of organic and inorganic fertilizer has a higher positive effect on microbial biomass and enhances soil health (Elkholy, et. al., 2010) and improves the use efficiency of recommended inorganic fertilizer and reduces its cost (Abedi, et. al., 2010).

The same finding was reported by Walia, et. al., (2010) that the integrated nutrient management resulted in increasing organic carbon content of the soil, available nitrogen, phosphorus and potassium from 0.390% to 0.543%, 171.7 to 219.3 kg ha^{-1} and 20.5 to 43.3 kg ha^{-1} respectively.

Table 2. Recommended Organic Soil Amendments + Mineral Fertilizer Combinations for K-deficient Soils

Fertilizer Combination			Application
Organic Inputs	+	Mineral Fertilizer	
(rate/tree/year)			
1. 10 kg Organic Amendments (5-7% NPK)	+	2.0 kg KCl (0-0-60)	Broadcast and fork-in 2 m away around the base of coconut
2. 2-6 kg Commercial Bioorganic fertilizer (5-7% NPK)	+	2.0 kg KCl (0-0-60)	
3. 10 kg Dried Animal Based (goat, cow, chicken manure)	+	2.0 kg KCl (0-0-60)	
4. 10 kg Seasoned Cocopeat	+	1.5 kg AS (21-0-0)	
5. Coconut dry leaves, Coconut husk, stipules, branches and other parts	+	2.0 kg KCl (0-0-60)	Mulch at the base of coconut trees (about 2.0 m radius)
6. Plant Based (ipil-ipil, *Flemingia*, *Gliricidia sepium* , *Rensonii*,	+	2.0 kg KCl (0-0-60)	Apply trimmed herbage at 2m away the base of coconut

Table 3. Recommended Organic Soil Amendments + Mineral Fertilizer Combinations for K-sufficient Soils

Fertilizer Combination			Application
Organic Inputs	+	Mineral Fertilizer	
(rate/tree/year)			
1. 10 kg Organic Amendments (5-7% NPK)	+	2.0 kg Common Salt	Broadcast and fork-in 2 m away around the base of coconut
2. 2-6 kg Commercial Bioorganic fertilizer (5-7% NPK)	+	2.0 kg Common Salt	
3. 10 kg Dried Animal Based (goat, cow, chicken manure)	+	2.0 kg Common Salt	
4. 10 kg Seasoned Cocopeat	+	1.5 kg AS (21-0-0)	
5. Coconut dry leaves, Coconut husk, stipules, branches and other parts	+	2.0 kg Common Salt	Mulch at the base of coconut trees (about 2.0 m radius)
6. Plant Based (ipil-ipil, *Flemingia, Gliricidia sepium , Rensonii,*	+	2.0 kg Common Salt	Apply trimmed herbage at 2m away around the base of coconut

Moreover, several studies revealed that the combined use of inorganic fertilizer with organic fertilizer like manure significantly increases soil organic carbon content, total N, and the available soil nutrients (Redda, et. al., 2017) improves the overall soil properties (Mahmood, et. al., (2017). For sustainable productivity, the combination of mineral with organic fertilizer has proved to be highly beneficial in terms of balanced nutrient supply (Ayeni and Adetunji, 2010) and significantly higher than yields from sole organic fertilizer application (Efthimiadou, et. al., 2010).

E. Recommended Combination of Organic Soil Amendments + Mineral Fertilizers + Arbuscular Mycorrhizal Fungi (AMF)

Arbuscular Mycorrhizal Fungi (AMF) colonizes plant roots in a symbiotic manner and extends far into the soil. Mycorrhizal fungal filaments in the soil are truly extensions of root systems and are more effective in nutrient and water absorption than the roots themselves. The symbiotic arrangements have been found in about 90% of all land plants and plant roots are hospitable sites for the fungi to anchor and produce their threads (hyphae). Also, large mass of fungal hyphae acts as virtual roots system for the plants, increasing the amount of water and nutrients that the plant may obtain from the surrounding soil.

AMF acquire N from decomposing organic matter and use this N principally for their own growth and metabolism (Hodge and Fitter, 2010). The large biomass and high demand of AMF means that they represent a global N pool equivalent in magnitude to fine roots and play a substantial and hitherto overlooked role in the Nitrogen.

Nitrogen is a limiting nutrient in many terrestrial ecosystems (Vitousek and Howarth, 1991). AMF can transfer inorganic N ($NO3^-$ or $NH4^+$) to their host plant (Govindarajulu, et al., 2005) but because these ions can readily move to the root zone via diffusion, it has been assumed that roots would not require mycorrhizal assistance to capture inorganic N, particularly because plants that form in ecosystem with high nitrification rates (Read, 1991).

Rillig, et al. (2001) suggested that contributions of mycorrhizal to soil carbon storage based on hyphal biomass in soil and roots may be an underestimate. The amount of C and N is glomalin (a recently discovered glycoprotein produced by AMF hyphae) represented a sizeable amount (Ca. 4-5%) of total soil C and N in the oldest soils. The results indicate that the microbial fungal carbon that is not derived from aboveground or below ground litter can make a significant contribution to soil carbon and nitrogen pools and can far exceed the contribution of soil microbial biomass (ranging from 0.08 to 0.2% of total C for the oldest soils). Table 4 presents the integration of AMF to the concept of Integrated Soil Fertility Management (ISFM).

Table 4. Recommended Commercial Soil Amendments +Mineral Fertilizer + Arbuscular Mycorrhizal Fungi Combinations for Bearing Palms

Soil K level	Rate (kg/palm/year)	Application
A. K-deficient soil	**Option 1:** 10 kg Commercial OSA + 2.0 kg KCl + 100g AMF **Option 2** 8-10 kg Seasoned Cocopeat + 1.5 kg AS + 100 g AMF	• Fertilizers - broadcast and fork-in 2 m away around the base of coconut • AMF – hole placement at 4 equidistant holes (25g/hole)
B. K-sufficient soil	**Option 1** 10 kg Commercial OSA + 2.0 kg NaCl + 100 g AMF **Option 2** 8 kg CCBOF + 2.0 kg NaCl + 100 g AMF	

In bearing palms, 100g of AMF will be inoculated to the root zone of existing bearing palms in combination to the application of Organic Soil Amendments (OSA) + Mineral Fertilizers (MF). A number of 04 equidistant holes will be prepared where 25g of AMF will be filled in every hole. The fertilization scheme aimed to replace ammonium sulfate with organic soil amendments thereby promoting the bio-healthy coconut agroecosystems.

The intermittent application of Organic Soil Amendments + Mineral Fertilizers will be done in the 1st and 2nd year. AMF will be integrated in the 1st year of fertilizer application. However, fertilizer application will be skipped in the 3rd year.

The virtual root system shall be assessed in the 2nd year thru soil sampling and laboratory analysis. In the absence of virtual roots system, re-inoculation of AMF shall be done in the 2nd year.

Recommendation for Coconut

- Apply 100g/bearing palm plus the recommended fertilizer.
- Reapplication of AMF will be done in the absence of virtual root system.

F. Effect of Integrated Soil Fertility Management to the Yield of Bearing Pams

Coconut productivity is greatly affected by fertilization management. Coconut response to fertilization can be assessed in terms of nut/tree/year, copra/nut and copra/tree/year. The response of coconut to integrated soil fertility management is shown in Figure 1. Yield increase ranged from 44.34% to 241.75% and 51.50% to 227.92% in terms of nut/ha/year and copra/ha/year, respectively. Among the fertilizer combinations, application of commercial Peat Soil + KCl had the highest yield increase in nut production (241.75%) and copra yield (227.92%). While the lowest yield increased was observed on the application of dried chicken manure + KCl with 44.34%% (nut/ha/year) and 51.50% (copra/ha/year) higher compared to unfertilized palms.

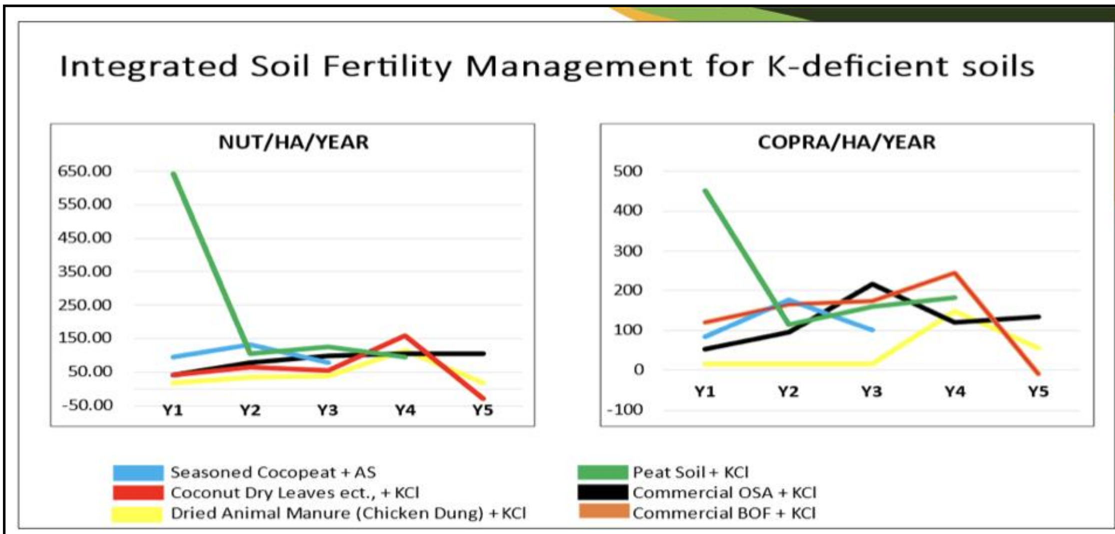

Figure 1. Yield increase (%) in response to integrated soil fertility management for coconuts planted in K-deficient soils.

The results revealed the importance of using different fertilizer sources to provide the needed nutrients of coconut to increase its productivity. Organic soil amendments is more effective if combined with Cl containing mineral fertilizer sources such as KCl. In K-deficient soil, KCl must be used in combination with other fertilizer materials to improve the K-content of the soil.

Yield increase (%) of coconut as response to integrated soil fertility management for K-sufficient soils is shown in Figure 2. Yield increase ranged from 89.88% to 279.53% and 81.23% to 260.29% in terms of nut production and copra yield, respectively. In terms of yield production, the combination of commercial BOF + CS had the highest nut (279.53%) and copra (260.29%) yield increase, respectively.

In general, organic soil amendments for coconut were more effective when combined with Cl-containing mineral fertilizer. Fertilizer combinations resulted to more than 80% yield increased over the unfertilized palms. In K-sufficient soil, common salt was

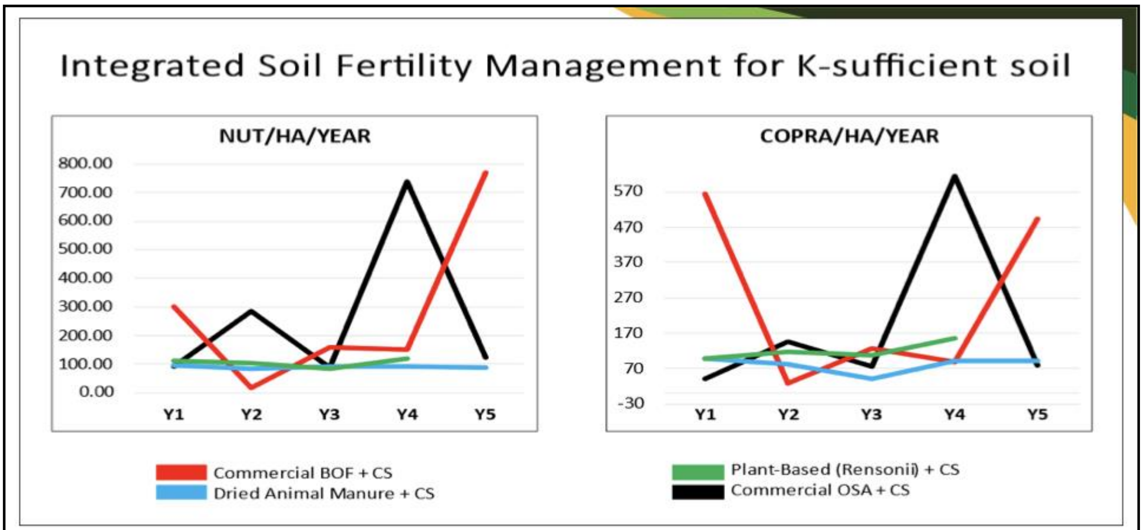

Figure 2. Yield increase (%) in response to integrated soil fertility management for coconuts planted in K-sufficient soils.

recommended as the cheapest source of chlorine for coconut.

CONCLUSION & RECOMMENDATION

The application of organic N containing fertilizer materials + KCl and Cl containing mineral fertilizers to address N, K and Cl deficiencies generated yield increase that ranged from 44.34% to 241.75% and 51.50% to 227.92% in terms of nut/ha/year and copra/ha/year, respectively.

The application of organic- N containing fertilizer materials + Cl-containing mineral fertilizers for K-sufficient soils resulted to a yield increase, which ranged from 89.88% to 279.53% and 81.23% to 260.29% in terms of nut production and copra yield, respectively.

The combined effect of organic soil amendments and mineral fertilizers reduced the amount required of both fertilizer materials. Improved soil fertility management through increased use of available organic soil amendments and improved farm management practices can result in positive gains in farm productivity.

The most evident advantage of adopting fertilization management is in the increase in yield that was realized.

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