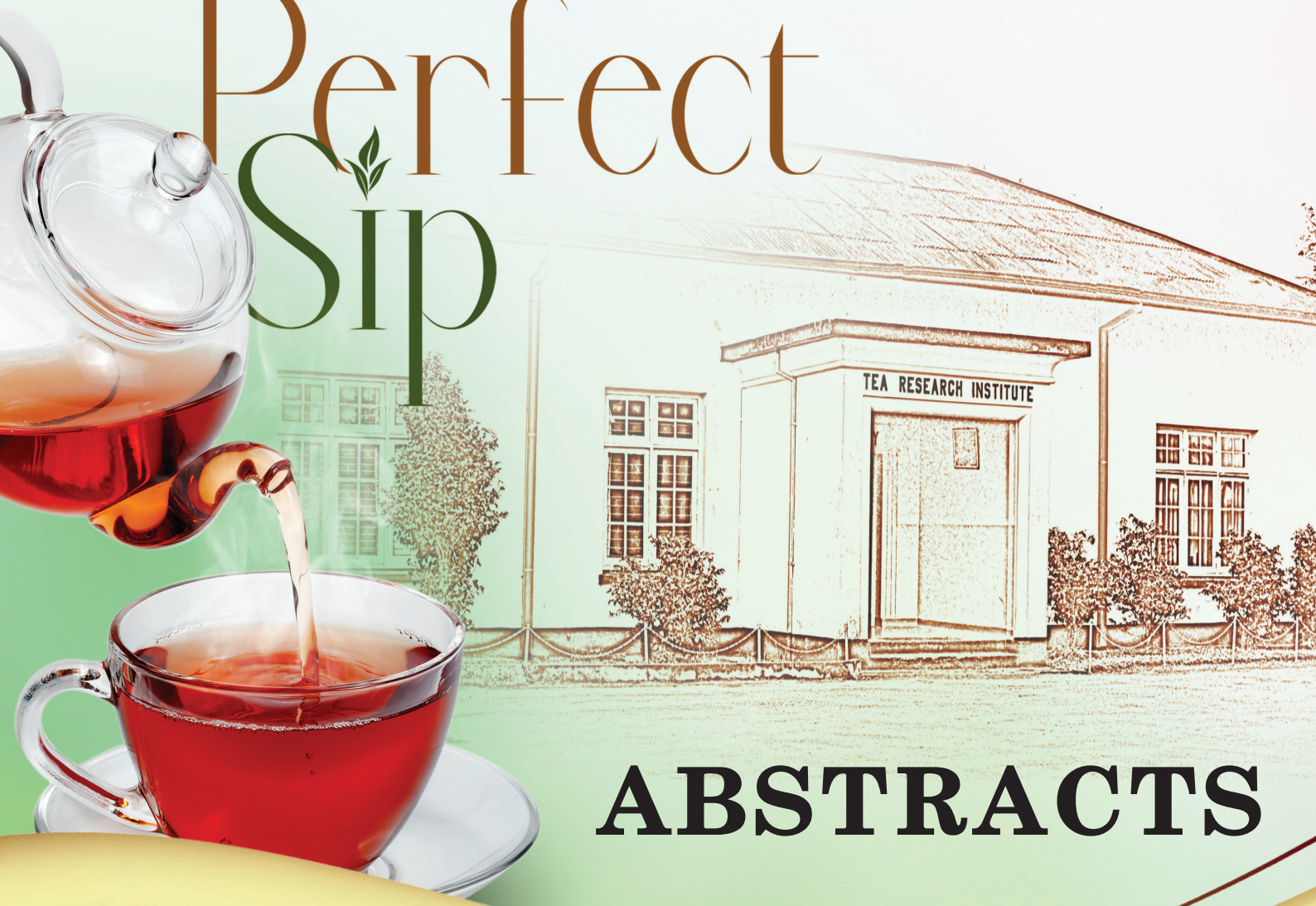
InTSym IX
Brewing Innovations
1925 | TRI | 2025

INTERNATIONAL TEA SYMPOSIUM

Perfect Sip: Bridging Innovations, Sustainability and Lifestyle

Perfect Sip



ABSTRACTS

THE TEA RESEARCH INSTITUTE OF SRI LANKA
SALUS NOSTRA UNITAS INCORPORATED
1925

TEA RESEARCH INSTITUTE OF SRI LANKA

International Tea Symposium

"Perfect Sip: Bridging Innovations, Sustainability and Lifestyles"

InTSym IX

Brewing Innovations

1925 | TRI | 2025

Organized by
Tea Research Institute of Sri Lanka
held on
10th and 11th November 2025
Cinnamon Grand, Colombo, Sri Lanka

Tea Research Institute of Sri Lanka
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PREFACE

It is with great pride and honour that International Tea Symposium (InTSym100) Organizing Committee present this *Abstracts of Proceedings* published in commemoration of the 100 years celebration of the Tea Research Institute of Sri Lanka (TRI). To mark this historic milestone, the Institute organized an International Research Symposium, inviting contributions from both Sri Lankan and foreign scientists engaged in advancing tea research and development.

The Symposium Secretariat received a total of 73 research papers covering a wide spectrum of topics related to tea including tea breeding, biotechnology, biochemistry, crop protection and sustainability, climate change, mechanization, process technology, extension, and socio-economics. Each submission underwent a rigorous review process, evaluated by at least two independent subject specialists, ensuring the quality and relevance of the scientific content. Final acceptance decisions were made by the Editorial Board.

This *Abstracts of Proceedings* compiles 49 selected abstracts, representing 34 oral presentations and 15 poster presentations, organized under seven thematic areas: *Innovations in Tea Crop Improvement and Biotechnology*, *Quality Improvement and Product Innovation*, *Competitiveness and Market Trends in Tea*, *Gender, Society and Tea*, *Innovative Approaches in Sustainable Crop Protection*, *Climate Resilience and Crop Sustainability*, and *Technology Transfer in Tea*.

By encompassing a diverse range of contemporary tea research from both local and international scientists, this publication aims to serve as a valuable reference and resource for researchers, academics, and industry professionals. The Symposium Secretariat extends sincere gratitude to all contributors for their dedication to advancing the global tea industry. It is our hope that these studies will inspire innovation, guide sustainable practices, and strengthen the future resilience of tea cultivation worldwide.

Dr. Niranjan Mahadevan
Dr. Chamila Pilapitiya
Dr. Dananjaya Kottawa-Arachchi
Dr. Sriharan Raguraj

InTSym100 Organizing Committee
Tea Research Institute of Sri Lanka
Talawakelle

EDITORIAL

It is with great pleasure that we present the *Proceedings of the International Tea Symposium*, bringing together innovation, tradition, and cutting-edge research in one of the world's most cherished beverage.

The year 2025 marks a historic milestone for the Tea Research Institute of Sri Lanka (TRISL), celebrating "100 years of Research Excellence" and pioneering contributions to the advancement of the tea industry, both nationally and globally. In celebrating this momentous milestone, the TRISL is hosting the Centenary Symposium under the theme *"Perfect Sip: Bridging Innovations, Sustainability, and Lifestyles"* bringing together a distinguished gathering of local and international researchers, academia, industry stakeholders, practitioners, and policymakers.

Since its establishment in 1925, TRISL has been at the forefront of scientific innovation and practical applications in tea cultivation, processing, and sustainability. The Centenary Symposium will no doubt provide a platform to reflect on the Institute's remarkable journey over the past 100 years while fostering dialogue on future directions and challenges in the tea sector.

This compilation of abstracts, comprising both local and international presentations, brings together diverse insights from across the tea value chain spanning genetic improvement, sustainable crop production and management, processing technology, socio-economic dimensions, marketing strategies, technology transfer, climate resilience and the revival of artisanal teas and cultural heritage. Together, these contributions reflect the dynamic interplay between tradition and innovation that is shaping the future of the global tea sector. The scholarly work compiled here provide timely insights and actionable solutions to inspire dialogue and guide the tea industry towards a more resilient and inclusive future.

We express our sincere gratitude to all authors and presenters for their valuable contributions, and to the reviewers for ensuring the quality and relevance of the papers. We also extend our heartfelt thanks to the InTSym100 Publication Committee whose dedication and expertise made this event and its proceedings a success.

As we celebrate 100 years of TRISL, we also look forward to continued collaboration and innovation in the dynamic world of tea. It is our hope that these proceedings will serve as a valuable resource and a springboard to inspire new ideas and partnerships for the decades to come.

Dr. M T Kumudini Gunasekare and Dr. M A Wijeratne
Editors-in-Chief
Proceedings of the International Tea Symposium 2025 - InTSym100
10th November, 2025

MESSAGE FROM THE PRESIDENT OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

It is with great pride and profound appreciation that I extend my heartfelt congratulations to the Tea Research Institute of Sri Lanka (TRI) on the momentous occasion of its Centenary. Completing 100 years of dedicated scientific service, from 1925 to 2025, stands as a remarkable testament to the Institute's unwavering commitment to advancing one of Sri Lanka's most iconic and economically vital industries.

Ceylon Tea has earned a distinguished reputation across the world for its exceptional quality, purity and heritage. The contribution of the Tea Research Institute to safeguarding this legacy is immeasurable. Through pioneering research, technological advancement and innovation in sustainable cultivation, the TRI has supported our nation's tea sector to remain globally competitive, even amidst evolving climatic, economic and market challenges.

The Centenary International Scientific Conference (InTSym100), scheduled for 10–11 November 2025, is a significant milestone that brings together local and global scientists, industry leaders and policymakers. This distinguished gathering will serve as an invaluable platform to share knowledge, strengthen strategic collaborations and shape the future direction of the global tea economy. I am confident that the discussions and outcomes of this conference will help accelerate transformation across the plantation sector.

The introduction of the TRI5000 series tea cultivars, especially designed to empower our smallholder community, which contributes over 75% of national tea production, demonstrates the TRI's strong alignment with national priorities. Such advances further reinforce the government's vision for a modern, resilient and high-value tea industry.

As we stride forward, Sri Lanka remains firmly committed to enhancing productivity, ensuring sustainability and securing greater returns for all stakeholders. The insights gained through this conference are directly aligned with our ambitious national goal of achieving USD 2.5 billion in tea export revenue and 400 million kilograms of production by 2030, reinforcing the tea industry as a cornerstone of Sri Lanka's robust and resilient future economy.

Let this centenary celebration inspire renewed dedication to strengthening the legacy of Ceylon Tea and elevating its future. I extend my best wishes for a highly productive and successful conference and for the continued excellence of the Tea Research Institute in the decades ahead.

Anura Kumara Dissanayake
President
Democratic Socialist Republic of Sri Lanka
10th November, 2025

MESSAGE FROM THE PRIME MINISTER OF THE DEMOCRATIC SOCIALIST REPUBLIC OF SRI LANKA

It is my pleasure to extend greetings to the Tea Research Institute of Sri Lanka (TRISL) on the occasion of its International Tea Symposium (InTSym100), marking one hundred years of scientific contribution and service to the tea sector. The theme, *"Perfect Sip: Bridging Innovations, Sustainability, and Lifestyles"* reflects the direction the industry must take, where research and innovation support future growth while sustaining the livelihoods that depend on tea, and maintaining the quality associated with Ceylon Tea.

As one of the world's oldest institutions dedicated solely to tea research, TRISL has played a central role in shaping the global standing of Ceylon Tea. Continued research will be vital as we work toward our national goals of producing 400 million kilograms of tea and achieving 2.5 billion US dollars in export revenue by 2030.

In an evolving global market, Sri Lanka must adopt new technologies, value-added products, and sustainability – focused practices to remain competitiveness. I hope the work presented at InTSym100, ranging from crop improvement and product development to sustainability, gender and society, and technology transfer – will offer important insights for the industry's future. Addressing climate – related challenges will also be essential to safeguarding the long-term viability of tea cultivation.

I also recognize the vital contribution of the women who from the backbone of our plantation communities, whose labour and resilience continue to sustain the industry. Ensuring that future research and policy frameworks support their well being, dignity, and economic security is fundamental to the progress we seek.

I further acknowledge the contributions of our international research partners; whose collaboration strengthens Sri Lanka's role in the global tea landscape. The Government remains committed to supporting research – led growth and to building a more resilient and sustainable tea sector.

As we mark a century of work, let us align our experience with innovation to ensure that "Ceylon Tea" continues to represent quality, responsibility, and national pride.

Dr. Harini Amarasuriya
Prime Minister of Sri Lanka
Democratic Socialist Republic of Sri Lanka
10th November, 2025

MESSAGE FROM THE MINISTER OF PLANTATION AND COMMUNITY INFRASTRUCTURE

The International Tea Symposium (InTSym100) is the flagship event among the series of centenary celebration events of the Tea Research Institute (TRI), functioning under the Ministry of Plantation and Community Infrastructure. This gathering is a vital mechanism for executing the Ministry's mandate to modernize and globally competitive the tea industry. Over the past century, the TRI has provided the technical and scientific backbone necessary for the industry's success. The Symposium offers an invaluable opportunity for policy-level evidence exchange, allowing us to translate cutting-edge global research into effective national strategies. Discussions will cover critical areas such as climate-resilient tea cultivation, value-addition techniques, and market diversification, all essential for securing a resilient supply chain. Furthermore, the event will highlight the R&D contribution necessary to support our smallholder community, which is crucial for achieving the 400 million kg production target. By attracting national and international experts, InTSym100 strengthens our international partnerships and ensures that 'Ceylon Tea' maintains its premier standing as a sustainable and high-quality product in a rapidly evolving global market.

K V Samantha Viddyarathna
Minister
Ministry of Plantation and Community Infrastructure
10th November, 2025

MESSAGE FROM THE DEPUTY MINISTER OF PLANTATION AND COMMUNITY INFRASTRUCTURE

The InTSym100 is a momentous occasion that directly addresses the technological and environmental challenges facing the Sri Lankan tea industry today. As the second-oldest tea research institute globally, the TRI has established a legacy of pioneering research. This Symposium is focused on translating this legacy into tangible, on-the-ground improvements for tea growers. The key focus areas, including the launch of high-performing tea cultivars and discussions on advanced pest and disease management, are critical for boosting productivity and reducing operational costs. My involvement is to ensure that the scientific breakthroughs presented at this international forum are efficiently integrated into practical extension services for regional plantation companies and the majority smallholder community. This proactive approach to sustainable productivity enhancement is vital. By promoting technological adoption and strengthening the R&D nexus between the TRI and the industry, we can not only enhance the quality and yield required to meet our 2030 export revenue targets but also ensure the socio-economic upliftment of the plantation communities, making the tea industry a more attractive and viable career path for future generations.

Sundaralingam Pradeep
Deputy Minister
Ministry of Plantation and Community Infrastructure
10th November 2025

MESSAGE FROM THE SECRETARY
MINISTRY OF PLANTATION AND COMMUNITY INFRASTRUCTURE

The administration and successful organization of the International Tea Symposium (InTSym100) on November 10-11, 2025, marks a major milestone in the Ministry's oversight of the Tea Research Institute's (TRI) Centenary year. This event is fundamentally a knowledge sharing and strategic planning exercise. The Symposium facilitates a necessary convergence of technical, commercial, and administrative stakeholders, ensuring that research priorities align perfectly with national policy objectives. From an administrative perspective, the outcomes will provide the evidence-based data required for crucial decision-making regarding resource allocation, investment in research infrastructure, and regulatory adjustments. The goal is to secure the necessary R&D contributions that propel the industry toward the national economic targets of $2.5 billion in export revenue and increased sustainable production. Furthermore, the Symposium's success solidifies our institutional capacity and international standing, showcasing Sri Lanka's ability to host and lead discussions on the future of the global tea trade, thereby creating a favourable administrative and investment climate for all partners.

B K Prabath Chandrakeerthi
Secretary to the Ministry
Ministry of Plantation and Community Infrastructure
10th November 2025

MESSAGE FROM THE CHAIRMAN
TEA RESEARCH BOARD

It is with great pride that I convey my greetings to the Tea Research Institute of Sri Lanka as it celebrates its Centenary and hosts this International Tea Symposium. Over the past century, the TRI has been instrumental in strengthening the foundation of the tea industry through science-based innovation, knowledge dissemination, and commitment to excellence.

The synergy between research and the commercial sector has ensured that "Ceylon Tea" remains one of the most trusted and admired brands globally. The collaboration between the Tea Research Institute and other commercial partners in the tea industry has been vital in ensuring the industry's resilience, especially in improving quality standards, environmental stewardship, and market competitiveness.

This *Abstracts of Proceedings* serves as a testament to the intellectual vitality of our researchers and the Institute's enduring contribution to global tea science. I take this opportunity to appreciate all those who continue to advance our shared vision for a sustainable and thriving tea industry.

Senior Professor W A J M De Costa
Chairman
Tea Research Board
Talawakelle

MESSAGE FROM THE DIRECTOR
TEA RESEARCH INSTITUTE OF SRI LANKA

It is my distinct honour and great pleasure to welcome you to the International Tea Symposium 2025 (InTSym2025) hosted by the Tea Research Institute of Sri Lanka, Sri Lanka. Since its establishment in 1925, the Institute has been the driving force behind the evolution of tea science blend with the heritage from agronomy and breeding to processing technology, environmental management, social and market-oriented research.

This gathering represents a unique intersection of tradition and innovation, where we celebrate the past, present, and future of one of the world's most beloved beverages.

The theme of the Symposium *"Perfect Sip: Bridging Innovations, Sustainability and Lifestyles"* invites us to reflect on tea's profound journey. InTSym2025 brings together scientists, policymakers, and industry stakeholders to reflect on the past, share present advancements, and chart the course for the future of tea research.

As the Tea Research Institute of Sri Lanka marks a century of pioneering research and service to the nation, I am delighted to present this *Abstracts of Proceedings*, which captures the spirit of scientific inquiry that has defined our journey. The publication offers a concise overview of the research presented during the symposium, highlighting the breadth and depth of our ongoing work.

I extend my sincere gratitude to all contributors, reviewers, sponsors, and organizing committees whose dedication made this event and publication possible.

Let us continue to uphold our commitment to scientific excellence and sustainable growth for the benefit of Sri Lanka's tea industry and beyond.

I wish you an inspiring and productive symposium.

Dr. Mahasen A B Ranatunga
Director / CEO
Tea Research Institute of Sri Lanka
Talawakelle

MESSAGE FROM THE CHAIRPERSON, INTSYM100

It gives me immense pleasure to convey this message on behalf of the organizing committee of the International Tea Symposium (InTSym100), scheduled to be held from 10th to 11th November 2025 in Colombo, Sri Lanka.

The InTSym100, organized under the theme *"Perfect Sip: Bridging Innovations, Sustainability and Lifestyles*" stands as the landmark event in the series of centenary celebrations of the Tea Research Institute of Sri Lanka. As such, InTSym100 serves as a timely platform for scientists, industry stakeholders, entrepreneurs, academics, and policymakers to exchange knowledge, share experiences, and better collaboration ensuring the long-term sustainability of the global tea industry. The symposium will consist of a keynote address, plenary speeches, oral and poster presentations, and round table discussions which will cover a range of interesting and interdisciplinary topics related to tea. Oral and poster presentations cover seven thematic areas *viz*. Innovations in Tea Crop Improvement and Biotechnology, Quality Improvement and Product Innovation, Competitiveness and Market Trends in Tea, Gender, Society and Tea, Innovative Approaches in Sustainable Crop Protection, Climate Resilience and Crop Sustainability, and Technology Transfer in Tea. As said in the theme itself, I am confident that InTSym100 will contribute to strengthening the connections between innovation, sustainability, and lifestyle and pave the way for continued excellence in tea research for generations to come.

I am sincerely grateful to our Chief Guest, Special Guest, Keynote Speaker, Plenary Speakers, invited dignitaries, session chairs, judging panel members, panel members of the roundtable discussions, presenters, participants, and well-wishers for their invaluable contributions in numerous ways towards the success of InTSym100. My heartfelt thanks also go to the reviewers for the time, efforts and expertise in evaluating manuscripts and to the editors for their significant contribution in refining the language and enhancing the quality of the contents. My deep appreciation goes to the Symposium Management Committee: Chairman of the Tea Research Board, Director, Deputy Directors, Chairperson of the Centenary Secretariat, and the Senior Accountant of the Tea Research Institute of Sri Lanka, for their continuous guidance and support since the beginning. A special note of gratitude is extended to my colleagues of the InTSym100 organizing committee and the members of the staff of the Tea Research Institute of Sri Lanka for their tireless commitment and teamwork throughout the journey of InTSym100. A special note of thank goes to Dr. S. Raguraj and the publication subcommittee for their exceptional efforts in materializing the Abstracts of Proceedings and the subsequent publications into your hands.

Finally, I wish InTSym100 all the very best. May it become a great platform that unites ideas for the progress of the tea industry, both locally and globally, and mark the beginning of another century of research excellence

Dr. Niranjan Mahadevan
Chairperson of the International Tea Symposium (InTSym100)
Tea Research Institute of Sri Lanka

KEYNOTE SPEECH

Dr. Rohan Fernando
Managing Director, Aitken Spence Plantation Managements PLC

I am privileged to have been invited to make this key note address at the Centenary Symposium of the Tea Research Institute of Sri Lanka (TRI). The TRI has been the APEX body for tea research in Sri Lanka and has been an integral part of Sri Lanka's Tea Industry, dating back to1867. The TRI has produced eminent and internationally acclaimed Scientists not only to head the Institute but several others who have served the Institute and had been world class Scientists in their own disciplines. Many of them have served overseas and pioneered several groundbreaking initiatives in tea research in Sri Lanka and brought the industry to its current status.

However, it is my view, that like most Government connected administrative bodies the TRI has also has suffered from lack of funds for research and new developments and also failed to attract and retain Scientists and other industry professional due to various structural deficiencies in the overall system. Unfortunately, this issue has never been addressed in the last several years.

The future of the Tea industry in Sri Lanka and the future of the Tea Research Institute is inextricably linked to each other. And therefore, the development and the future direction of the TRI will be very crucial for taking Sri Lanka's Tea Industry to meet the global and local challenges.

Both the Tea industry and the TRI have several inherent weaknesses which have not been addressed throughout the years despite both having several strengths too. Whilst a strategy has to be developed to address the weaknesses and build on the strengths of the tea industry. Local and global opportunities and threats are also looking ahead and need to be addressed.

The international tea market has also had its own challenges with consumer's trends taking a new direction whilst threats from other beverages are also an important aspect to consider.

Sri Lanka is also grappling with the question of increasing or limiting production which needs a market-oriented approach and a scientific basis. Lessons learnt from other countries will also be a factor to be reckoned with in developing a broad strategy for the future role of tea in the Sri Lankan economy and the role played by the TRI in sustaining the Sri Lanka's Tea Industry.

I will endeavor to share my insights in the key note address and also how the Tea industry and the TRI could position itself as a key player in this important industry to maintain its global position and be an important contributor to Sri Lanka's economy.

CONTENTS

Technical Session 1: Innovations in Tea Crop Improvement and Biotechnology

Technical Session 2: Quality Improvement and Product Innovation

Technical Session 3: Competitiveness and Market Trends in Tea

Technical Session 4: Gender, Society and Tea

Technical Session 5: Innovative Approaches in Sustainable Crop Protection

Technical Session 6: Climate Resilience and Crop Sustainability

Technical Session 7: Technology Transfer in Tea

Poster Presentations

Session 1

Innovations in Tea Crop Improvement and Biotechnology

New Candidate Tea (*Camellia sinensis* L.) Cultivars of TRI 5000 Series for Low - Country Tea Growing Regions in Sri Lanka

Piyasundara J H N*, Ranatunga M A B, Kottawa-Arachchi J D, Ranaweera K K, Mudalige A K, Udayangani J M K, Dayarathna G D N N, Jayarathna H W M M M, Damayanthi M M N, Vithanage N M, Senanayaka P D, Godavita B M G K, Karunajeeva D G N P, Mahadhevan N, Amali R K A, Mahindapala K G J P, Mahinda T G N, Alwis P D De, Munasinghe C E, Nishanthi H, Liyanaarchchi C J, Tharangika H B, Kalhari J K A D, Pathiranage S R W, Hemakumara R B L, Chamindra M A and Koddithuwakku K A C L

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Abstract

Among tea growing regions in Sri Lanka, lower elevations, popularly known as "Low Country", contributes to about two-third of the total tea production of the country. Through a series of experimentations, five new tea accessions (84, 174, 278, 12/11, 23/5) have been identified as candidate cultivars of TRI 5000 series suitable for the low country tea growing regions. All these accessions possess compatible yields with standard cultivar, TRI 2026. Moreover, they possess high tolerance to drought, major pests (shot hole borer, nematodes and low country live wood termites) and diseases (stem and branch canker), prevailing in the low country tea growing regions. In addition, two of these accessions (174 and 12/11) have exhibited moderate amenability to mechanical harvesting. These desirable attributes of the new accessions in terms of productivity and resilience to biotic and abiotic stresses will provide better opportunities to tea growers in the low country tea growing regions to face emerging challenges such as climate change impacts and scarcity of skilled workers.

Keywords: *Candidate cultivars, drought, Low country, tea accessions, TRI 5000 Series*

Screening of Bangladesh Tea (*Camellia sinensis* L.) Germplasm for Drought Tolerance

Hossain M I[1], Ashrafuzzaman M[2], Hossain M A[2], Rahman M M[2], Fakir M S A[2], Sarwar A K M G[2] and Arefin M R[1,2,*]

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Abstract

Drought stress is a major abiotic factor limiting tea (*Camellia sinensis* L.) productivity worldwide, particularly in regions in Bangladesh, where climatic variability is increasing. This study aimed to screen a diverse collection of tea germplasms for drought tolerance under nursery and field conditions with a view to identify promising genotypes suitable for cultivation in drought-prone areas of the country. Previously-selected five test clones (A/17/7, Mz/39, Sh/9/65, B/8/93 and A/8/8) along with a control clone (BT2) were evaluated based on morphological, physiological, and biochemical parameters such as plant height, root length, root volume, vertical length of root, dry matter, Relative Water Content (RWC), proline accumulation, total polyphenol content, and reducing sugar. Four treatments *viz*. T0 (Maintaining 36% soil moisture content) as the control with three moisture- stress treatments: T1 (Maintaining 30% soil moisture content), T2 (Maintaining 24% soil moisture content) and T3 (Maintaining 18% soil moisture content) were used for assessing drought tolerance both under nursery and field conditions. Cluster analysis indicated clear variations among the genotypes, where B/8/93 was distinguished as the most drought tolerant and A/8/8 as the most drought sensitive clone. Mz/39 exhibited wide adaptability under field conditions, while the remaining cultivars (BT2, Sh/9/65, and A/17/7) were grouped as having moderate tolerance to drought. The study provides a foundation for genetic improvement of drought resilience in tea, contributing to the long-term sustainability of the Bangladesh tea industry.

Keywords: *Biochemical trait, drought, morpho-physiological parameters, tea, water relation*

Optimization of the Somatic Embryogenesis Protocol for *In-vitro* Mutagenesis of Tea [*Camellia sinensis* (L.) O Kuntze]

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Abstract

Tea breeding programme in Sri Lanka have produced diverse tea varieties. However, Sri Lankan tea cultivars have limited genetic diversity due to the non-native origin of tea. This study aimed to develop an efficient *in vitro* mutagenesis protocol for tea to enhance the genetic diversity of existing elite tea cultivars by incorporating advanced mutation breeding and tissue culture techniques. Explants (leaf and cotyledon) were collected from tea cultivars recommended by the Tea Research Institute of Sri Lanka. MS based media supplemented with varying concentrations of BAP (13, 18, 22, and 27 µmol) was used to identify a suitable culture medium for generating somatic embryos. Somatic embryos derived from leaf and cotyledon explants were then evaluated for their suitability for irradiation at a dosage of 17 Gray of gamma radiation. To determine the optimal timing for *in vitro* mutagenesis, five different maturity stages of somatic embryos (1, 2, 3, 4, and 5 weeks after inoculation) were subjected to irradiation. A BAP concentration of 13 µmol was found to be optimal for inducing somatic embryos from leaf explants, providing a solid foundation for a robust somatic embryogenesis protocol using leaf explant. Cotyledon cultures showed higher somatic embryo formation than leaf cultures and were more suitable for *in vitro* mutagenesis. After irradiation, a significantly higher survival rate was observed: 24% for cotyledon derived somatic embryos at the 5-week maturity stage and 13% for leaf derived somatic embryos at the 4-week maturity stage.

Keywords: *Cotyledon, in-vitro mutagenesis, leaf, somatic embryos, tea*

Identification of Drought Tolerance Accessions of Tea (*Camellia sinensis* L.) in Low Country Wet Zone of Sri Lanka

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Abstract

The vulnerability and impacts of climate change vary across different regions. In Sri Lanka, low-country tea-growing areas have been identified as highly susceptible to climate-related stresses**.** Therefore, implementing appropriate interventions, such as the cultivation of drought-tolerant cultivars, is crucial to mitigate these adverse effects. Several physiological and biochemical parameters namely, photosynthesis rate, transpiration rate, stomatal conductance, relative water content (RWC), and total proline content have been identified as effective indicators for screening drought-tolerant cultivars**.** This study aimed to assess the drought tolerance of newly introduced tea accessions suitable for cultivation in the low-country wet zone of Sri Lanka. Three control cultivars (TRI 2025, TRI 2026, and TRI 2023) and eleven accessions (107, 131, 133, 163, 62, 23/5, 12/11, 10/1, 29, 751 and 294) were evaluated using a newly developed and validated Drought Susceptibility Index (DSI). Moisture stress conditions led to reductions in gas exchange parameters and RWC, while proline content increased. During the moisture stress period, most of the assessed parameters in the accessions showed significant differences compared to the control cultivars. Physiological, biochemical, and yield-related responses to drought were evaluated across two dry spells. Based on the collected data and calculated DSI values, accessions 107, 131, 12/11, 133, 23/5, and 163 were identified as drought-tolerant, while accessions 10/1, 29, 294, and 62 were classified as drought-susceptible.

Keywords: *Accessions, drought stress, DSI, tea, tolerance*

Floral and Leaf Morphological Characterization of Old Tea Genetic Resources in Hakgala Botanic Garden, Sri Lanka

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Abstract

To overcome the narrow genetic diversity in commercial tea cultivation, it is essential to introduce new genetic resources into the existing germplasm. The Hakgala Botanic Garden (6.54°N, 80.40°E, 1380 m above mean sea level) in Sri Lanka harbors a valuable collection of ancient tea genetic resources, comprising approximately 150 unique introduced tea accessions. A study was conducted to assess the genetic diversity of these resources and identify unique genotypes for conservation and utilization in plant breeding. A comprehensive investigation was carried out on the old seedling tea (OST) population at Hakgala Botanic Garden using 15 leaf morphological descriptors and 17 floral morphological descriptors. Leaf morphological characterization revealed significant heterogeneity among the OST genotypes. Diversity indices, including Shannon's index and evenness values, indicated notable phenotypic differentiation, with internode length showing the highest diversity (H' = 1.22). A Neighbor-Joining (NJ) tree based on morphological data grouped the genotypes into three major clusters, with several OST accessions displaying morphological similarities to reference tea cultivars. Floral morphological studies showed a significant variation in certain floral characteristics, such as stigma position and style length. Three accessions, HKG63, HKG1, and HKG53, displayed unique floral morphologies and, hence, came out as distinct clusters. The possibility of using these special accessions in breeding programmes is strengthened by these genetic differences. These findings highlight the significance of the Hakgala OST population as a reservoir of untapped genetic diversity. The study identifies several genotypes as promising candidates for future tea breeding and conservation efforts, contributing to the sustainable utilization of Sri Lanka's tea genetic resources.

Keywords: *Germplasm conservation, genetic variation, old seedling tea, morphological characterization*

Investigating the Genotypic Differences in Critical Temperatures for Pollen Germination and Pollen Tube Growth of Selected Tea (*Camellia sinensis*) Cultivars

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Abstract

Tea (*Camellia sinensis*) seed gardens, produce polyclonal seeds through natural cross-pollination. Growers are now using these seeds as an alternative to vegetatively propagated tea seedlings in low-productive lands. However, a decline in seed production is reported in most tea seed gardens, may possibly be due to low pollination success of tea flowers due to high ambient temperatures. The study quantified the optimum and maximum temperatures for pollen germination and pollen tube growth of 13 tea cultivars and their photosystem II heat tolerance (PHT) using the pollen samples collected from germplasm of the Tea Research Institute of Sri Lanka. The optimum temperature for pollen germination ranged from 22.37 °C to 25.84 °C, with no significant differences among widely grown cultivars. Cultivar-specific variations in the optimum temperature for pollen tube growth were observed, ranging from 21.54 °C to 25.83 °C. The critical temperature threshold for PSII heat damage was between 46.90 °C and 50.71 °C, with cultivars TRI 3013 and TRI 2016 exhibiting higher critical temperature tolerance. In the up-country region, the average daytime temperature (22–26 °C) closely aligns with the optimum range for pollen germination and pollen tube growth. However, in the low-country regions, daytime temperatures typically range from 26–34 °C, exceeding the optimal temperature for pollen germination and pollen tube growth. These findings suggest that the lower pollination success observed in low-country seed gardens may be attributed to daytime temperatures surpassing the optimal range for pollen germination and tube growth. Therefore, improving the microclimatic conditions of low-country seed gardens with a view to lower the daytime temperatures can enhance pollination success and overall reproductive efficiency.

Keywords: *Critical temperature, Photosystem II heat tolerance, Pollen germination, Pollen tube growth, Tea seed gardens*

Session 2

Quality Improvement and Product Innovation

Unlocking Healthier Brewing Alternatives: Differential Biochemical Profiling of Traditional and *in vitro* Callus-Derived Sources for Decaffeinated Tea

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Abstract

Growing global demand for innovative tea products, especially decaffeinated tea, highlights a critical need, as excess caffeine can negatively impact sensitive individuals. Traditional tea breeding for low-caffeine varieties is challenging due to the perennial nature of tea plant and long breeding cycle. Our research addresses this by deploying tissue culture techniques for *Camellia sinensis* clone UPASI 9, aiming for sustainable decaffeinated tea production. We successfully established a protocol for callus induction from nodal segments. A comparative biochemical analysis was then performed on infusions from tea produced through conventional processing and tea produced using callus tissues derived from nodal explants of the same clone. Results revealed significant differences: tea produced through conventional processing method exhibited high levels of polyphenols (17.65%) and catechins (13.95%). In stark contrast, callus-derived tea showed a negligible caffeine content (0.58%) and increased amino acids (4.60%) besides offering a unique flavor. Further molecular (qPCR studies with *TCS1* gene) and non-targeted metabolomic profiling using GC-MS confirmed the unique decaffeinated nature of the tea processed from callus. This pioneering study demonstrates the feasibility of using callus as a viable, sustainable alternative for decaffeinated tea production. This approach mitigates challenges like seasonal variability and environmental threats inherent in traditional cultivation, offering a method that can reduce land use and carbon footprint. Future research will focus on optimizing processing, assessing health implications, and exploring market potential of decaffeinated tea produced from callus.

Keywords*: Callus, Decaffeinated tea, In-vitro culture, Metabolomics, Tea processing*

Acknowledgement: *This work was supported by the Department of Biotechnology, Government of India under Grant [number BT/PR45280/NER/95/1918/2022].*

Development of a Hydrolyzed Collagen Incorporated Green Tea Blend and FTIR Characterization of the Developed Blend

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Abstract

A novel product of collagen incorporated green tea was developed to enhance the anti-aging benefits through combining hydrolyzed fish collagen, green tea, hibiscus powder, and apple flavor powder (maltodextrin as a carrier). A descriptive analysis was performed to select the most preferred blend with hydrolyzed collagen. The tea infusion obtained from the most preferred collagen green tea blend had a pH of 5.25. The final product is composed of 3.23% crude protein, 5.25% moisture, 1.08% fat, and 5.34% ash. The crude protein content of green tea is 1.23%. When hydrolyzed collagen was added, the protein content rose from 1.23% to 33.23%. The collagen tea was filtered at two temperatures (60 ^{o}C and 25 ^{o}C). Collagen denaturation usually occurs at 60 ^{o}C, and brewing at 25 ^{o}C is done to prevent the denaturation. The total phenolic content (TPC) and total flavonoid content (TFC) of the collagen green tea brewed at 25 ^{o}C were 16.65 mg GAE/g DW and 9.45 mg RE/g DW, respectively. When brewed at 60 ^{o}C, the TPC and TFC increased to 32.90 mg GAE/g DW and 25.06 mg RE/g DW, respectively. This approach resulted in higher phenolic and flavonoid content at 60 ^{o}C compared to 25 ^{o}C. Fourier Transform Infrared Spectroscopy (FTIR) was used to examine the physicochemical properties of the product to find potential molecular interactions. The presence of collagen was confirmed by the presence of Amide A (3263 cm^{-1}), Amide I (1630 cm^{-1}), and Amide II (1518 cm^{-1}) absorption peaks in the pure fish collagen. The FTIR spectra of the products revealed very slight changes, but these do not have any health implications, suggesting molecular interactions between collagen and green tea polyphenols, which may contribute to improved stability and bioavailability. When comparing the FTIR spectrum of pure fish collagen and the FTIR spectrum of collagen green tea, the Amide A band (3263 cm^{-1}) in the FTIR spectrum of collagen green tea exhibited increased absorption, while the Amide I (1630 cm^{-1}) and Amide II (1524 cm^{-1}) bands showed decreased absorption. This study provides valuable insight into the potential of functional beverages in promoting skin health and preventing aging, and paves the way for further research and product development that satisfy consumer demand.

Keywords: *Collagen Green Tea, Fish Collagen, FTIR spectroscopy, Green Tea*

Validation of Improved Method for Theanine Determination in Matcha Tea by Inter-laboratory Study

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Abstract

ISO 19563:2017 is the official method for determining theanine, the main amino acid in tea (*Camellia sinensis* (L.) O. Kuntze). It specifies the use of high-performance liquid chromatography (HPLC). Leaf tea samples are ground, mixed with boiling water, stirred using a magnetic stirrer, and filtered through filter paper for analysis. Because matcha tea is a pre-ground green tea, the grinding step can be eliminated. However, most matcha tea is ground very finely to achieve a smooth texture. As a result, stirring with boiling water causes clumps to form, and filtering the mixture through a filter paper causes clogging. These issues complicate matcha tea extraction. Consequently, an alternative method involving centrifugation and ultrasonication was proposed for determination of theanine in matcha tea. In this study, an inter-laboratory investigation was performed to validate an improved extraction method for matcha tea. Thirteen participating laboratories independently analyzed the six test materials (six pairs of blind duplicates). After removing outliers, the repeatability (RSD_r) and reproducibility (RSD_R) of the evaluated methods were 1.8–5.9% and 5.2–7.4%, respectively, in the concentration range of 0.5269–4.257% w/w. The Horwitz ratio (HorRat) values for the theanine concentration were calculated to be 1.3–1.9. This study demonstrated that the improved method has acceptable precision.

Keywords: *HPLC, inter-laboratory study, matcha tea, theanine*

Acknowledgment: *The authors gratefully acknowledge the support of a grant from Japan Tea Central Public Interest Incorporated Association.*

Evaluation of Biochemical Composition in Field-Grown Tea (Cultivar: TRI 2043) using Agrophotovoltaic-Driven LED Lighting

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Abstract

Agrophotovoltaic (APV) systems integrate agriculture with solar energy generation on the same land, offering sustainable solutions for food and energy production. In order for the specialty teas to stay competitive in the global market, it is beneficial to enhance the biochemical composition of the Sri Lankan tea cultivars. This study examined the effects of wavelength provided by photovoltaic-powered LED light on yield and quality parameters of mature field-grown tea plants (cultivar TRI 2043), mainly focusing on pigment and polyphenol contents. An APV system-powered LED lights provided blue and red lights to tea plants. Sunlight served as the control. Yield, shoot density, and anthocyanin, polyphenol, and chlorophyll contents in tea leaves were measured. The light spectrum measurements showed that the control plants received natural light at 317-886 nm, while plants under APV systems received blue light at 420-460 nm, and red light at 600-700 nm wavelengths. The anthocyanin was highest in the 1st and 2nd leaves, while polyphenol peaked in the bud and declined with leaf maturity. Chlorophyll content increased with leaf maturity. The anthocyanin in the bud, 1st and 2nd leaves were significantly reduced ($p<0.05$) under blue light compared to control, while red light showed no significant change. Blue light significantly increased ($p<0.05$) polyphenol, chlorophyll a, and total chlorophyll contents ($p<0.05$). None of the light treatments significantly affected ($p<0.05$) shoot density or tea yield. In conclusion, the results revealed that blue light can be effectively used to increase chlorophyll and polyphenol levels in tea leaves. The wavelength effects on anthocyanin content warrant further study.

Keywords: *Agrophotovoltaic system, anthocyanins, polyphenols, specialty teas, tea quality*

Session 3

Competitiveness and Market Trends in Tea

Market Potential for Ceylon Tea Geographical Indication: An Economic and Policy Assessment

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Abstract

Sri Lanka's tea sector is a cornerstone of the national economy and a major source of rural livelihoods, with both economic and socio-cultural significance. Since its introduction during British colonial rule in the 19th century, tea from Sri Lanka, known under the reputed designation Ceylon (the former name of Sri Lanka) Tea has attained global recognition for its high quality and origin-specific characteristics. The tea industry contributes substantially to Sri Lanka's GDP and foreign exchange earnings, accounting for approximately 51% of agricultural exports, 10.9% of total exports, and nearly 0.7% of GDP in the recent years. It also supports the livelihoods of over one million people throughout the value chain. Sri Lanka exports over 95% of its tea production, in bulk or consumer packaging. The country ranks as the third-largest global tea exporter and the second-largest black tea exporter, with key markets including Iraq, Saudi Arabia, Libya, and the UAE. However, these markets show signs of declining in market penetration and overreliance, despite their high Revealed Comparative Advantage (RCA) for Sri Lankan tea. There is considerable untapped market potential for Sri Lankan black tea in countries such as the USA, Canada, Australia, and the UK, especially for consumer-packaged tea in quantities less than 3 kg. However, Sri Lanka's ability to expand into these markets is hindered by several challenges, including a heavy reliance on traditional export destinations, limited investment in branding and promotional activities, and difficulties in maintaining consistent product quality. This paper aims to identify emerging market opportunities and proposes the recognition and registration of "Ceylon Tea" as a Geographical Indication (GI) as a strategic branding tool to enhance international competitiveness. Using trade data from the International Trade Centre (ITC) and World Integrated Trade Solution (WITS), along with Key Informant Interviews and legal analysis of GI frameworks, the study explores how stronger legal protection and quality assurance through GI protection in facilitating Ceylon Tea entry into new high-potential markets.

Keywords: *Ceylon tea, geographical indication, legal framework of GI, market promotion, untapped potential*

From Leaf to Cup: Forces behind Tea-Based Radical Innovations in Sri Lanka

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Abstract

Proven health benefits of tea (*Camellia sinensis*) have driven many developed countries to invest in large-scale, tea-based innovations. However, most tea-producing countries, including Sri Lanka, continue to function primarily as bulk tea suppliers, thereby earning lower returns from tea exports. This study aimed to: 1) examine whether the development of tea-based radical innovations significantly impacts firm performance and 2) identify the key determinants influencing the production of such innovations in Sri Lanka. A questionnaire survey was conducted among 43 out of 180 registered exporters in the country. Data were analyzed using Mann-Whitney U test, Principal Components Analysis and Generalized Linear Model. Results revealed that tea-based radical innovations contribute significantly on firm performance (sales gain). With respect to determinants: firm strategy (number of food technologists, number of market destinations, number of professionally qualified employees in marketing and management accounting); firm resources (direct links to plantations and processing factories); and science and technology qualifications of Chief Executive Officers, have significant positive impact on production of tea-based radical innovations whereas firm size showed a significant negative impact on the same.

***Keywords**: Firm performance, radical innovations, tea (Camellia sinensis), value-addition*

The Paradox of Organic and Sustainable Certifications in Nepalese Orthodox Tea: Do Producers Truly Benefit?

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Abstract

Organic and sustainable certifications have become critical for tea producers seeking access to premium international markets. However, their economic implications in Nepal's orthodox tea industry continue to be a subject of debate. Organic and sustainable certifications such as United States Department of Agriculture (USDA) Organic and Rainforest Alliance (RA) are key market access tools but their economic viability is uncertain due to high certification and compliance costs. This paper explores whether Nepalese orthodox tea producers truly gain from the certifications or if the financial burden outweighs the advantages. This study examines the economic impact of certification through a set of economic indicators, including production costs, costs of certification, prices, profit margins, and benefit-cost ratios. A census survey of 69 tea companies in Ilam, Nepal, was conducted, employing structured interviews. Using a combination of descriptive and inferential statistics, including one-way ANOVA, a comparison was made among 3 groups, organic, RA and uncertified producers. The findings indicate that while certification provides higher per-unit prices, net financial benefits are low due to high certification costs. Benefit-cost ratio differences between certified and non-certified producers suggest that certification may not necessarily result in higher profitability. The study concludes that unless certification costs are reduced or external financing is provided, small and medium-scale producers will be unable to sustain certification. These findings contribute to the ongoing discourse on the economics of certification in the tea sector.

Keywords: *benefit-cost analysis, economic impact, Nepal tea, organic certification, rainforest alliance*

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Sustaining Competitive Advantage in the Tea Industry: A Case Study on Innovation, Quality Management, and Operational Efficiency in XYZ Tea Company

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Abstract

The global tea industry is a significant contributor to economic growth, with Sri Lanka being one of the largest exporters of tea worldwide. In this context, maintaining a competitive advantage is crucial for Sri Lankan tea companies, especially as they face evolving consumer demands, market competition, and environmental sustainability challenges. This research explored how innovation, quality management, and operational efficiency contribute to sustaining a competitive edge in the Sri Lankan tea industry, focusing on XYZ Company, a prominent tea manufacturer. This study adopted a qualitative case study approach, with data collected through semi-structured interviews from 12 authorities in XYZ Company, covering areas such as factory, field, and office. Thematic analysis revealed key themes: product innovation and holistic innovation management strategies, standardization for global consistency, sustainability through efficiency, and integrating technology in production. Further, the themes identified were: adapting to market dynamics, cultural and organizational resistance to change, balancing tradition and modernity, and regulatory compliance *vs*. innovation flexibility. These themes together illustrate the company's integrated approach to innovation, quality management, operational efficiency, and the challenges and opportunities it faces in sustaining a competitive advantage. The findings suggested that XYZ Company has made significant progress in innovation and operational efficiency, but further potential exists through expanding product innovations, adopting holistic innovation management strategies, and increasing technological integration. These findings offered valuable insights for improving the competitive position of Sri Lankan tea companies in the global market.

Keywords: *Innovation, operational efficiency, quality management, Sri Lanka, tea industry*

Factors Influencing the Ceylon Tea Export Market Share in East Asian Countries

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Abstract

East Asia tea market is a sophisticated market with both high consumption and production. Preferences for tea consumption are changing rapidly among consumers. This study examines the key factors influencing the export market share of Ceylon tea in East-Asia, a region that presents both challenges and opportunities. The purpose of this research is to identify and analyze these factors in order to provide valuable insights that can improve Ceylon tea export performance. The research employed a quantitative data analysis. The analysis was conducted using a multiple linear regression model. The main findings indicate that innovative technological practices, obtaining international certifications and the implementation of diverse marketing strategies; product differentiation and branding, significantly enhance the export performance. The production and export of value-added tea products emerged as a key driver of market share expansion. However, challenges such as high production costs adversely affect the competitiveness of Ceylon tea. This emphasize the importance of modern strategic and technological approaches. The growing segment of health-conscious consumers; Millennials and Gen Z is shaping demand for natural, organic, wellness-focused teas, Ready-to-Drink variants and premium teas. With these, Ceylon tea's reputation for high quality presents a competitive advantage, where stringent quality standards apply. To remain competitive in the East Asian tea market, Ceylon tea exporters must adopt innovative marketing strategies, effectively reduce production costs, and focus on product quality and emerging consumer preferences. Improving trade fair participation, exploring market trends, and maintaining quality control are some of the key recommendations.

Keywords: *Competitive advantage, consumer preference, East-Asian tea market, export market share, tea market trends*

Session 4

Gender, Society and Tea

In the Shadows of Ceylon Tea; Post-Colonial Feminist Analysis on Intimate Partner Violence and Access to Justice Among Malaiyaha Tamil Women in Sri Lanka's Tea Plantations

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Abstract

The global tea industry has celebrated the flavour of Ceylon Tea for centuries while erasing the historical and continuing marginalization faced by Malaiyaha Tamil women who sustain its production. Unlike the broader sociological literature on gender-based violence, few scholarly contributions explored the interplay between substance of law and lived realities in access to justice among female victims of intimate partner violence within Malaiyaha Tamil community. This study employs a post-colonial feminist lens to critically examine how Intimate Partner Violence (IPV) within Malaiyaha Tamil women is protected, obscured and perpetuated within socio- economic structures of Sri Lanka's tea plantations. It argues that while domestic and international legal frameworks nominally protect women against IPV, the law has failed to account for compounded vulnerabilities resulted through double colonisation, caste, ethnicity, culture and plantation patriarchy. Using doctrinal and intersectional approach, the study reveals how outdated legal definitions, institutional inertia, language barriers and systemic exclusion undermines Malaiyaha women victims from accessing justice. Through a critical analysis of law and secondary qualitative data, the study demonstrates an urgent need to reimagine legal protections by focusing on lived realties and addressing power asymmetries that underpins intimate partner violence and broader socio-economic order of plantation community. Ultimately, it calls for an urgent effort to bridge the gap between law and reality in application, highlighting that legal remedies alone are inadequate without deconstructing the structures of historical and social oppression.

Keywords: *Intimate Partner Violenc, Legislations, Malaiyaha Tamil Plantation Community, Post-colonization, Plantation Patriarchy*

Analysis of Factors Influencing the Transformation from Conventional to Organic Tea Farming in the Uva High Grown Region

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Abstract

Organic tea cultivation has gained significant prominence within Sri Lanka's agricultural sector due to its inherent capacity to address sustainability concerns and cater to the escalating global demand for organic products. This study aims to explore the factors influencing farmers' decisions to adopt organic practices and examines the challenges associated with the transformative process. The sample of the study was 100, consisting of 50 organic farmers and 50 conventional farmers. Primary data were collected using a semi-structured questionnaire encompassing socio-demographic characteristics, key drivers for transformation, awareness level of organic cultivation, attitudes towards organic cultivation, farmers' level of organic cultivation and compliance with organic standards. The questionnaire was pre-tested to ensure its reliability. Descriptive analysis and binary logistic regression were used to analyze data. Higher profits and environmental friendliness are compelling reasons to choose organic tea farming over conventional tea farming. The results indicate that farmers are substantially aware of organic farming practices. Farmers' compliance behaviour towards organic standards (OS) is not universally consistent and can vary across different standards due to several factors. These factors include the availability of support services, financial capacity, and the level of awareness regarding potential hazardous contaminants. Land Extent, higher profit, attitude on organic tea cultivation, and farmers' knowledge about organic tea cultivation are statistically significant with $p < 0.05$. This study contributes to the existing body of knowledge by shedding light on the drivers and barriers of transitioning from conventional to organic tea cultivation in Sri Lanka. The outcomes hold practical implications for policymakers, researchers and stakeholders seeking to facilitate and promote sustainable agricultural practices within the tea industry.

Keywords: *Conventional, organic, tea cultivation, transformation*

The Adoption of Innovative Mechanization Technologies in Corporate Sector Tea Plantations in Sri Lanka: A Case of Mechanized Harvesting

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Abstract

Mechanized harvesting (MH) is not widely practiced in Sri Lanka's tea plantations, despite the severe worker shortage (WS) and higher production costs, which directly affect tea prices and thus the consumer. Research on the reasons behind poor MH adoption has received little attention in recent years. The main research objective of this cross-sectional study was to examine the determinants of MH adoption in corporate sector tea plantations in Sri Lanka. The study employed a mixed-methods research approach, combining a survey and a case study. Managers were selected using the proportionate stratified sampling technique, covering all tea-growing regions of Sri Lanka. The data were analysed using partial least squares structural equation modelling (PLS-SEM), content, and thematic analysis. Findings revealed, the key determinants that collectively influenced the behavioural intention to adopt MH are organizational factors, managers' attitude, facilitation, and crop factors, while managers' innovativeness, perceiver ease of use, and usefulness had an indirect effect on MH adoption. This study makes a significant new contribution by introducing key determinants of MH adoption, while filling an empirical gap in the study context. From a practical perspective, it is suggested to share the experiences of successful stories with measurable outcomes, while establishing plantation company policies that favour MH, and facilitate this process through skill development training on machine.

Keywords: *Adoption, determinants, labour shortage, mechanized harvesting, tea plantation, Sri Lanka*

An Investigation of Planters Insights for Alternative Worker Deployment Models of Tea Plantations in Sri Lanka

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Abstract

Tea industry remains a vital component of the national economy of Sri Lanka. However, worker shortage is one of the critical challenges in this sector. Consequently, in the recent years, there have been a shift in worker deployment method from conventional-estate practices to Alternative Worker Deployment Models (AWDMs) as part of the solutions to address worker shortage. Nevertheless, there is a lack of comprehensive understanding regarding the AWDMs employed in tea plantations, their features, the extent of their adoption and the perceptions of the planters on AWDMs. Thus, the present study aimed to assess planters' perspectives on AWDMs. Structural interviews were conducted to collect the data, by purposively selecting twenty-six (26) executives from different plantation companies who adopted and continued AWDMs. The findings revealed that the worker deployment method has been changing depending on the circumstance and time. The study found that the effectiveness of each model heavily relies on how well the system aligns with the estate conditions and the perspectives of close supervision of workers. Finally, most of the plantation executives have identified that implementing AWDMs is beneficial to the estate as they reduce cost of production and the burden of maintaining uneconomical tea lands. Additionally, digitization in plantation management may enhance worker productivity and ultimately the estate productivity. The advancement of worker deployment models towards the concept of decent work represents a prospective development for the plantation industry in Sri Lanka.

Keywords: *Alternative worker deployment, contract farming, uneconomical tea lands, worker scarcity*

Effect of Incentives on the Collective Action of Farmer Organizations: A Case Study of Tea Smallholding Development Societies in Sri Lanka

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Abstract

Farmer Organizations (FOs) are community-based, predominantly non-profit organizations operating independently of the state and the private sector. The existence of FOs is greatly challenged worldwide in the present neoliberal economic context. Therefore, it was imperative to find a solution for the present situation faced by farmer organizations, considering the contextual factors and other dynamics. The government of Sri Lanka established the Tea Smallholding Development Societies (TSHDS), the FOs, in the tea sector by a legislative act to facilitate the smallholders' development, marketing, welfare and financing. This study sought to evaluate the collective action of the TSHDS and investigate the influence of incentives on the collective action of TSHDS. TSHDS served as the unit of analysis, with 120 units selected through cluster, stratified, and random sampling technique. The sampling units were drawn from seven major tea smallholding districts in Sri Lanka. Data were collected from key officials and members of TSHDS using structured questionnaires. Descriptive analysis, Spearman correlation test, Wilcoxon sign rank test, and factor analysis were employed to analyze the data. Results revealed that tangible and non-tangible economic benefits generated within the entity act as an incentive and cyclically promote the collective action of the members in a virtuous cycle. The commercialization of FOs leads to enhance voluntary cooperation in the TSHDS. This study emphasizes the importance of having an internal mechanism within the TSHDS to generate benefits through collaborative activities. Finally, this study recommends removing government intervention in controlling FOs and adopting an appropriate commercialization approach.

Keywords: *Collective action, economic benefits, farmer organization, incentive, Tea Smallholding Development Societies*

Session 5

Innovative Approaches in Sustainable Crop Protection

Insecticide Resistance Status of Tea Looper (*Hyposidra talaca)* in Northeast India's Tea Ecosystems and its Probable Resistance Mechanism

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Abstract

The Tea Looper, *Hyposidra talaca* Walker (Lepidoptera: Geometridae), is considered one of the most damaging tea pests in India. Looper infestations in the tea-growing regions of Northeast India pose a significant risk to the tea industry, which is a crucial contributor to the nation's economy. Despite the implementation of various control measures such as application of Deltamethrin 2.8EC and Bifenthrin 8SC, their effectiveness remains limited, exacerbating the threat posed by climate change and inefficient pest management strategies. The present study evaluated the insecticide tolerance status of *H. talaca* across different tea-growing regions in Northeast India. A relative susceptibility study of different regions across Northeast India revealed significant differences in tolerance levels. In this study, varying levels of susceptibility to Deltamethrin 2.8% EC, Quinalphos 25% EC, Flubendiamide 20% WG, and Emamectin benzoate 5% SG, were found with a resistance coefficient that ranges from 0.49-46.87-fold, 0.53-42.47-fold, 0.39-25.27-fold, and 2.22-6.44-fold, respectively. Dooar's population of *H. talaca* showed higher tolerance compared to other regions in Northeast India. Detoxifying enzymatic analyses of general esterase (GE), glutathione-s-transferase (GST), and cytochrome P450 (CYP450) in the tea looper revealed a positive correlation with increasing cuticle thickness explored through a scanning electron microscopy. Furthermore, gut bacteria isolated from *H. talaca* larvae exhibited high deltamethrin degradation efficiency, suggesting their role in enhancing insecticide resistance through detoxification. The findings of this study provide valuable insights for the development of insecticide resistance management strategies and the integrated pest management of *H. talaca.*

Keywords: *Cuticle thickness, cytochrome P_{450}, gut symbiotic bacteria, Hyposidra talaca, general esterase, glutathione-S-transferase, relative susceptibility*

Biochemical Parameters to Identify Shot-Hole Borer (*Euwallacea fornicatus*) Resistance in Tea Cultivars: Emphasis on Polyphenols, Catechins, and Caffeine

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Abstract

Shot-hole borer (SHB) (*Euwallacea fornicatus*) is a major pest threatening tea (*Camellia sinensis*) plantations in Sri Lanka. Conventional SHB resistance screening relies on variable natural infestation levels, which leads to inconsistent results. This study aimed to establish a screening protocol based on biochemical parameters to identify SHB-resistant tea cultivars and accessions. Resistance levels were assessed through beetle-settling bioassays and biochemical analyses. Results of the bio-assay revealed that the cultivars and accessions showed varying levels of resistance to SHB viz. Resistant (Accession 43, TRI 2023), Moderately resistant (TRI 5006, TRI 5002, Accession 208), Moderately susceptible (TRI 5005, TRI 2025) and Susceptible (Accession 88). Biochemical analysis performed using bark material revealed that Accession 43 and TRI 2023 categorized as resistant to SHB had significantly lower caffeine ($p<0.05$) concentration of 2.46 mg/g and 2.85 mg/g, respectively at pre-infestation and it was increased to 6.48 mg/g and 5.24 mg/g at post-infestation. In contrast, Accessions 88, TRI 5005 and TRI 2025 which were categorized as susceptible to SHB exhibited higher caffeine levels (6.02 mg/g, 5.31 mg/g and 5.08 mg/g respectively) prior to infestation and increased further up to 17.5 mg/g, 16.17 mg/g, and 15.75 mg/g respectively, after infestation. Moreover, the results indicated a significant decrease ($p<0.05$) in total catechin concentration across all cultivars after infestation, while polyphenol levels varied depending on the specific cultivar. Cluster analysis identified two distinct clusters at the maximum linkage distance. The results of biochemical analysis revealed a significant variation among cultivars in terms of both SHB infestation levels and secondary metabolite responses. These findings suggest that lower caffeine and specific catechin contents can be used as a biochemical marker to identify tea cultivars that are resistant to SHB infestation.

Keywords: *Camellia sinensis, Pest resistance, Shot-hole borer, Secondary metabolites, Screening*

Non-conventional Management Strategies of Live-Wood-Eating Termite in Tea Plantations in North-East India

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Abstract

Live-wood-eating termites are responsible for considerable damage to young and mature tea plants throughout North-East India. Termite infestation of tea bushes leads not only to economic losses but also ruins several years of effort put into to growing tea. This study examines the efficacy of various non-conventional approaches to manage live-wood-eating termite problems in tea plantations of Tripura and Assam located in North-East India. Two field trials were conducted in these two agro-climatic regions. Ten non-conventional treatments were imposed including the application of biological agents such as *Metarhizium anisopliae*, *Heterorhabditis indica* (EPN), and inorganic compounds *viz.* boric acid, lime and alum, either alone or in combination. Application of water and thiamethoxam 25WG were used as untreated control and standard (conventional) treatments respectively. The experiments were conducted in a randomized complete block design (RBD) with three replicates. Treatments were applied over the collar-area twice with an interval of three months and observations were recorded up to twelve months. The results revealed that *M. anisopliae* and EPN treatments were highly effective in controlling termites, recording up to 93.33% reduction in infestation, which was significantly better than the standard treatment (thiamethoxam 25WG) as well as the untreated control (water application). Therefore, these non-conventional treatments, can be used in developing an integrated biological management package for sustainable termite control in tea ecosystems.

Keywords: *Entomopathogen, Live-wood-eating termites, North-East, nonconventional, tea plantation*

Endophytic Fungi from Tea Cultivars: Identification and *in vitro* Antagonism Against *Fusarium ambrosium*, a Symbiont of Shot Hole Borer (*Euwallacea fornicates*)

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Abstract

Tea (*Camellia sinensis*) is the most widely consumed beverage globally and plays a vital role in the Sri Lankan economy. Shot Hole Borer (SHB), *Euwallacea fornicates*, is one of the major tea pests in Sri Lanka. The fungus, *Fusarium ambrosium* is an obligate symbiont of SHB. Microbial biocontrol agents can effectively inhibit *F. ambrosium*, suggesting a potential strategy for managing SHB. The intimate association of fungal endophytes with plants offers a unique opportunity for their potential application in plant protection and biological control of pests and diseases. This study aimed to isolate and characterize endophytic fungi from selected tea cultivars and to evaluate their potential antagonistic activity against the symbiont *F. ambrosium* in dual culture assays. Out of 30 endophytic fungal isolates, six fungal isolates demonstrated significant antagonistic activity (ranging from 50.60 to 74.69 %) against *F. ambrosium*. Based on the ITS sequences of the rDNA region, four endophytic isolates were identified as *Diaporthe spp*., and two as *Coprinellus disseminates*. Association of endophytic fungi with tea plants could contribute to enhanced resistance against SHB infestation by suppressing its symbiont and offer a novel biological control strategy for SHB management.

Keywords: *Coprinellus disseminates, Diaporthe spp., endophytic fungi, Fusarium ambrosium, Shot Hole Borer*

Session 6

Climate Resilience and Crop Sustainability

Quantity-Intensity Relationship of Potassium and Magnesium in Tea Growing Soils of the Low-Country in Sri Lanka

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Abstract

Soil potassium (K) and magnesium (Mg) play a vital role in influencing both the yield and quality of orthodox black tea. This study aimed to evaluate the behavior of soil potassium and magnesium in low-country tea growing soils of Sri Lanka. Soils were equilibrated with varied concentrations of potassium and magnesium and thereby quantity (Q) and intensity (I) parameters were determined and the relationship was plotted to ascertain the buffering capacities. The potential buffering capacities of potassium for all soil series tested ranged from 1.14 $x10^4$ mg $kg^{-1}M^{-2/3}$ to 1.52$x10^4$ mg kg^{-1} $M^{-2/3}$ demanding frequent fertilization to increase the nutrient use efficiency. Labile K was also low, ranging from 24- 42 mg kg^{-1}. K specific sites of Weddagala, Dodangoda and Pallegoda series ranged from 54 - 60 mg kg^{-1}, while it was 200 mg kg^{-1} in Malaboda series. Potential magnesium buffering capacities observed for Malaboda, Weddagala, Dodangoda and Pallegoda soil series were 0.09 x 10^4, 0.09 x 10^4, 0.09 x 10^4 and 0.07 x 10^4 mg kg^{-1} $M^{-1/6,}$ respectively, indicating sufficient levels for tea plant growth. These soils appeared to have more magnesium-specific sites than potassium-specific sites, enabling greater magnesium retention than potassium.

Keywords: *Activity ratio, Magnesium, Potassium, Potential buffering capacities, Quantity Intensity Isotherms*

Design and Development of an End Effector for an Unmanned Tea Harvesting System

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Abstract

Tea is the second-most-consumed beverage globally and a vital contributor to Sri Lanka's economy, generating over $1.4 billion annually and supporting nearly 10% of the country's population. However, labour shortage, high costs, and inefficiencies in manual harvesting pose significant challenges to the sustainability and quality of Ceylon Tea. This research presents the design and development of a detaching and gripping mechanism for tea shoots, to be integrated into an unmanned selective tea harvesting device, such as a drone or a land robot, to enhance operational tea harvesting efficiency while maintaining high-quality standards. The developed metal gripper, driven by an MG995 servo motor, produced a gripping force of 11 N at 4 cm from the motor axis, which ensured the successful detaching force of the tea shoots and holding them until transfer to the collection basket. Tested on TRI 2043 and TRI 3072 tea cultivars at cutting angles of 90° and 45°, the gripper ensured plucking with minimal shoot damage with lesser pressure at 90^{o} cutting angle by the gripper. Field trials assessed harvesting speed, gripping accuracy, and system durability, demonstrating a cutting and holding time of 2 seconds per shoot (1800 shoots per hour) compared to the manual rate of 4–6 shoots per second (equivalent to 14,400-21,600 shoots per hour). The study highlights the system's potential to be mounted on an unmanned plucking device, laying the groundwork for sustainable mechanized tea harvesting. Future improvements based on different cultivars and under different environmental and management conditions will further refine its real-time capabilities and broaden applications in precision agriculture, ensuring long-term viability for the tea industry.

Keywords: *Ceylon tea, gripping mechanism, MG995 servo motor, tea shoot harvesting, unmanned plucking device.*

The Trends in Climate and Determination of Climate-Yield Relationships in Different Tea-Growing Regions of Sri Lanka During the Period from 2010 to 2024

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Abstract

The objective of this work was to identify the temporal trends in key climatic variables in locations representing different tea-growing regions of Sri Lanka during the last 15 years (2010-2024) and to determine climate-yield relationships. Daily meteorological data from five locations, *viz.* Talawakelle, Ratnapura, Hantana, Kottawa and Passara, were computed into monthly means of maximum (T_{Max}), minimum (T_{Min}) and mean (T_{Mean}) temperatures and monthly totals of rainfall (R_F), pan evaporation (E_T) and sunshine hours (SSH). Primary water balance (W_B) was computed as the difference between monthly totals of R_F and E_T. Change in each climatic variable was computed on a monthly basis as the difference (*i.e.* anomaly) in its monthly value from the respective monthly mean during the five-year reference period 2010-2014. Anomalies of climatic variables showed different temporal trends at different locations. Talawakelle, Hantana and Kottawa showed significant increasing trends in T_{Max} whereas Ratnapura and Hantana showed increasing trends in T_{Min}. All locations except Passara showed increasing trends in T_{Mean}. Ratnapura and Kottawa showed significant increasing trends in R_F whereas the other three locations did not show significant temporal trends. The pooled data set from all locations showed a combination of increasing monthly temperatures (0.036, 0.018 and 0.026ºC y^{-1} for T_{Max}, T_{Min} and T_{Mean} respectively) and increasing monthly rainfall (2.71 mm $month^{-1}$ y^{-1}). The best-fitting multiple regression models for climate-yield relationships in all locations included the second-order polynomials of a temperature-related variable (T_{Max} or T_{Min}) and a water-related variable (R_F or W_B). Estimated temperature thresholds showed that the current monthly temperatures in Ratnapura and Kottawa have already exceeded the thresholds beyond which yields begin to decline. In contrast, current temperatures in Talawakelle are close to the threshold while those in Hantana and Passara are still below the threshold. Estimated water-related thresholds show that increasing R_F or W_B will have positive impacts on tea yields in Ratnapura and Hantana, but negative impacts in other locations. The findings of this study provide a foundation for developing measures to enhance the climate resilience of Sri Lankan tea crops. The varying directions and magnitudes of climate change observed across different tea-growing regions, as demonstrated in this analysis, highlight the need for region-specific adaptation strategies.

Keywords: *Climate change, tea yield, temperature, rainfall, water balance*

Nutrient Losses Through Surface Runoff in Different Soil Conservation Practices in Mid Elevation Tea Lands in Sri Lanka

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Abstract

Soil nutrient loss occurs naturally through soil erosion, runoff, leaching and burning of crop residues, but this process has accelerated due to improper land and crop management. Minimizing of nutrient loss is crucial under the climate change, especially in steep agricultural lands like tea plantation in hilly area. This study was conducted to evaluate the effectiveness of soil conservation measures (SCMs) in reducing nutrient loss in a mature tea field at Kenilworth Estate, Ginigathhena (6°59' N, 80°29' E), located at mid-elevation (Maskeliya soil series). The slope of the study area was 60–72%. Erosion plots were arranged in Randomized Complete Block Design (RCBD) with four treatments; stone terrace (T), stone terrace with Vetiver grass (TV), terrace wall (TW) as soil conservation measures (SCM), and tea without conservation (TO) as control. Runoff were collected to the sediment tanks attached to the plots to analyze nutrients; Available Nitrogen (AN), Available Phosphorous (AP) and Potassium (K) from October 2020 to November 2021 with 5970 mm rainfall. The NO_3^--N concentration in runoff was not significant in different SCMs and NH_4^+-N concentration in runoff was significantly low in TV. The NH_4^+-N and NO_3^--N removal value in TV was 1.3 and 0.8 kg ha^{-1} yr^{-1} respectively. The amount of AP removed by runoff was significantly higher in TO (2.1 kg ha^{-1} yr^{-1}) than the SCMs; 0.9,0.4,0.5 kg ha^{-1} yr^{-1} in T, TV, TW respectively. K loss through runoff was not significant among treatment and lower in SCMs. TV was the most effective nutrient saving measure, reducing AN, AP and K losses by 6.9 (78%), 1.7 (80%) and 7.8 (86%) kg $ha^{-1}yr^{-1}$respectively due to combination of physical and biological measures.

***Keywords**: Climate change, nutrient loss, soil conservation, soil erosion, steep agriculture*

Session 7

Technology Transfer in Tea

Cultivating Innovation: Influence of Social Capital and Extension Services on Technology Adoption among Sri Lankan Tea Smallholdings

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Abstract

The smallholder tea farming in Sri Lanka, is currently grappling with declining productivity and intensified environmental and economic pressures. Studies on influence of social capital and agricultural extension services on technology adoption are vital to address these critical challenges. This research investigates how various dimensions of social capital (bonding, bridging, and linking) and agricultural extension services impact on technology adoption. Anchored in Social Capital Theory, Innovation Diffusion Theory, and the Theory of Planned Behaviour, this quantitative inquiry employed a multi-stage stratified random sampling approach to gather data from 452 smallholder tea farmers across the key tea-growing districts of Kandy and Badulla. Structural Equation Modelling (SEM) was subsequently utilized to examine the intricate relationships between the identified variables. The findings suggest that access to effective extension services combined with bonding and bridging social capital, plays a role in promoting technology adoption, which in turn yields substantial improvements in sustainability of tea smallholdings. These insights underscore the pressing need for the consolidation of farmer networks, enhancing the provision of relevant and tailor-made-extension services, and promoting inclusive technology adoption strategies to ensure the long-term resilience and productivity of Sri Lanka's tea smallholder sector. Consequently, policymakers, agricultural extension organizations, and development practitioners are urged to incorporate these findings into on-going and future tea sector development programmes.

Keywords: *Agricultural Extension Service, PLS-SEM, social capital, technology adoption, tea smallholders*

Evaluating the Effectiveness of the Digital Farm Field School Extension Approach for Technology Dissemination for Tea Smallholdings in Kandy District in Sri Lanka

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Abstract

The tea smallholding sector occupies a pivotal position within the tea industry in Sri Lanka; however, it faces numerous challenges, *viz* technological deficiencies, a shortage of skilled labour, limited access to inputs, low productivity, and high production costs. To address these issues, the Farmer Field School (FFS) approach was piloted by the Tea Small Holdings Development Authority, evolving into the Digital Farmer Field School (DFFS) format during the COVID-19 pandemic. This study aims to evaluate the effectiveness of the DFFS in increasing farmers' adoption of agricultural practices, productivity, and income. Using a stratified sampling technique, 50 smallholders who participated in DFFS and 50 non-participants were selected from five Grama Niladhari Divisions in Kandy District. A cross-sectional survey was conducted with a pretested instrument, ensuring reliability (Cronbach's alpha of 0.8224). Descriptive analysis, hypothesis testing, correlation and multiple regression were employed to explore relationships. Results indicated significant differences between DFFS and non-participants (NDFFS) at $p = 0.05$ in ICT literacy, knowledge and practice adoption, land productivity, and average income. The multiple regression model was fitted successfully ($p < 0.05$), showing that 92% of the variance in DFFS effectiveness was explained by ten independent variables such as organizational assistance, facilitation conditions, effort expectancy, income, age, and gender. However, family workforce, education, and ICT affordability did not demonstrate significant relationships. The study concludes that DFFS effectively enhances agricultural knowledge and practices among smallholders, highlighting the need for policymakers to implement DFFS approaches for technology transfer and engage various farmer groups and stakeholders in Sri Lanka.

Keywords: *Adoption, Digital farmer field school, Effectiveness, ICT literacy, Tea smallholders*

Bringing Tea Technology to the Farmer Doorstep: Participant's Perception on the Effectiveness of Mobile Crop Clinic Approach in the Low Country Tea Growing Region of Sri Lanka

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Abstract

Understanding farmers' perspectives on the mobile crop clinic approach is vital for optimizing its implementation and ensuring its contribution to improved livelihoods and productivity in the tea sector. This study investigated farmers' perceptions regarding the effectiveness of this novel extension approach. A sample of 120 was selected among the tea smallholders who participated in mobile clinics representing the three major tea growing districts (*i.e*. Ratnapura, Galle and Matara) from October 2024 to March 2025. Data were collected using pre-tested questionnaire which included the basic information, previous exposure to the tea extension services and perceived benefits received from mobile clinics. As per the results, mobile clinics had been perceived as one of the most suitable extension approaches for the tea sector in terms of perceived benefits such as time and cost saving, efficiency and easiness in soil analysis and receiving more than one service at a time. Simultaneously, the respondents had perceived inadequacy of time to get knowledge on the essential general aspects of tea as a limiting factor, since mobile clinics were more targeted on addressing regional specific issues. While welcoming the joint effort made by public and private institutes in conducting mobile clinics, smallholders preferred keeping this as a toll-free service. Further, the farmers' perception was significantly correlated with their type of involvement in tea cultivation (full-time or part-time) and the level of fulfilling their objectives through this mobile clinic service.

Keywords: *Agricultural extension, farmer's perception, mobile crop clinics, tea smallholders, Sri Lanka*

Effectiveness of Advisory Videos in Educating Tea Smallholders in the Mid-Country and Uva Regions in Sri Lanka

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Abstract

The use of advisory videos is becoming prominent in agricultural extension, particularly for reaching small-scale farmers with timely and targeted information. This study was conducted to test the effectiveness of video-based advisory services in enhancing the knowledge of tea smallholders in the Mid-country and Uva tea-growing regions in Sri Lanka, focusing on three key areas: nursery management, foliar fertilizer application, and labour wage. According to the farmers' perspective, some problems were associated with the lack of access to the updated and valid sources of information. A design-based research approach was adopted. The research process comprised three stages: audience analysis, advisory video development, and video evaluation. This study was conducted during the period from December 2024 to March 2025. Based on the audience analysis results, ten short video clips (4– 8 minutes) were developed using documentary and interview-style formats. A pre-test and post-test design was implemented with 30 smallholders, randomly assigned to two groups to assess knowledge levels before and after viewing the videos. Data were analyzed using the paired sample t-test. The results indicated significant knowledge improvement after watching the videos across the selected topics ($t = 5.19$, $p < 0.005$). Hence, the video-based extension can have a significant impact on the knowledge improvement of tea smallholders, and it can serve as a valuable tool to supplement traditional agricultural training. For greater impact, focus on interactive content, regional customization, and integration with other extension activities are required. Furthermore, the learning outcomes of the tea smallholders varied significantly with their educational background and digital media literacy. This study highlights the potential of digital media in agricultural extension and recommends further research on long-term knowledge retention, technology access, knowledge improvement, and farmer adoption rates.

Keywords: *Advisory videos, Digital media, Tea smallholders, Design-based research, Video-based learning*

Managers' Perception on Crop Productivity and Training Needs of State-Managed and Regional Plantation Company Tea Estates in Mid-Country, Sri Lanka

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Abstract

The tea estate sector in Sri Lanka plays a vital role in sustaining national tea production. In this context, training and awareness programmes are essential for enhancing both the quality and quantity of tea production and for improving the livelihoods of employees. This study examines the perception of estate managers on crop productivity and training needs of state-managed and Regional Plantation Company estates in the Mid-country region. A descriptive cross-sectional survey was conducted among 30 estates, representing both categories, using a structured questionnaire. Data were analyzed through descriptive statistics and the Mann–Whitney U test. Results indicated that the majority of estate managers in both categories have studied up to or above the diploma level and had more than 15 years of experience in tea plantation management. Insufficient training and awareness among staff and workers (75%) were identified as a key factor contributing to lower productivity. Significant differences were observed between state-managed and Regional Plantation Company managed estates in terms of investment in crop development and social development of human capital. Findings further revealed that most estates in the Mid-country region conduct training programs every three or six months. The estate managers emphasized that training in cultivation practices and productivity improvement are the key priority areas. The study highlights the importance of organizing tailor-made training programs integrated with need assessments and pre- and post-evaluations. Further, the study concludes the necessity to initiate training and awareness projects in collaboration with the Human Resource Departments of estates and training and awareness agents in the tea sector.

Keywords: *Crop productivity, Estate managers, Regional Plantation Company, State-managed estates, Training and awareness*

Poster Session

Differentiation Between Organically and Conventionally-Grown Tea Using Nitrogen Isotope

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Abstract

Consumer awareness of sustainable food production has increased over the past two decades, raising concerns about the health and environmental impacts of chemical fertilizers, pesticides, and herbicides. This trend has led to a high demand for organic food, with consumers prioritizing sustainability and health benefits over price. Tea (*Camellia sinensis*) is a globally consumed beverage rich in antioxidants. The quality of tea is influenced by genetic makeup, geographical conditions, and processing methods. Organically grown tea, which is cultivated without synthetic chemicals, is gaining popularity due to concerns over the environmental risks and potential health hazards associated with conventionally-grown tea, which may contain chemical residues. However, the certification process for organic tea is complex, highlighting the need for a scientifically-sound detection method to support and encourage organic tea production. This study focuses on differentiating organic and conventionally-grown tea using stable nitrogen isotopes. A total of 44 organic and conventional tea samples were collected from the highland regions of Sri Lanka. The nitrogen isotope composition was measured in tea samples using an elemental analyzer coupled with isotope ratio mass spectrometry (IRMS). The results showed that organic tea samples had higher $\delta^{15}N$ values than conventionally-grown tea. This study confirms the potential of $\delta^{15}N$ values as a supportive analytical approach for organic food certification and authenticity verification.

Keywords: *Authenticity, IRMS, organic certification, tea, stable isotope, verification*

Image Processing Algorithm to Estimate Tea Concentration for a Perfect Sip

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Abstract

This study presents a novel approach in estimating tea (*Camellia sinensis*) - BOPF (Broken Orange Pekoe Fannings) concentration using image processing and regression modeling. Since tea brewing is prone to human error, an automated concentration detection mechanism could be useful in ensuring high-quality tea that meets consumer expectations. In this study, tea solutions were prepared by brewing varying masses of tea leaves (0.0005 kg to 0.007 kg in increments of 0.0005 kg) in 0.0001 m^3 of water at 373 K for 120 seconds. Images of the solutions were captured under consistent lighting, and the Red (R) component of RGB values was extracted from three regions of interest, around the center, 150 pixels to the left, and 150 pixels to the right. The average R-value for each sample was calculated to represent color intensity and correlated with tea concentration using linear regression to understand how variations in tea concentration influence the R-value. The model produced a predictive equation with an R^2 value of 0.91, indicating a strong correlation between tea concentration and color intensity. The model successfully predicted the concentration of an unknown tea solution based on its red component of the RGB value, demonstrating its practical utility. The average accuracy of the model was determined to be 87.5%, and matching environmental conditions during sample testing with those in the correlation-building setup could further improve accuracy. This study demonstrates an efficient, scalable, and cost-effective tea quality assessment method using image processing and statistical modeling, suitable for industrial applications.

Keywords*: High quality tea, image processing, regression modeling, tea concentration*

Optimizing Oolong Tea Processing Parameters for DT 1 Tea Cultivar in Sri Lanka

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Abstract

Processing of Oolong tea from tender shoots of the tea plant involves solar withering, indoor withering, shaking inside a bamboo cylinder, fixing, ball rolling, roasting, drying, grading and packing. This study focused on optimizing the processing parameters for increasing the quality of Oolong tea produced from Sri Lankan DT1 cultivar. This study employed three-time durations over the key stages: solar withering (20 minutes, 30 minutes, 40 minutes), indoor withering (6 hours, 9 hours, 12 hours), and shaking in a bamboo cylinder (10 minutes, 20 minutes, 30 minutes). A total of 27 treatment combinations were tested along with the reference Oolong tea sample imported from China, and it was subjected to preliminary sensory evaluation. According to preliminary sensory evaluation, 12 samples were selected for secondary sensory evaluation and determination of important biochemical constituents. The present study identified 30 minutes of solar withering at 25 °C-35 °C temperature, 40%-75 % relative humidity (RH), and 300-1000 Lux of light intensity, followed by 6 hours of indoor withering at 25 °C-30 °C and 50 %-70 % RH, and 30 minutes of shaking in a bamboo cylinder as the most suitable processing combination for Oolong tea processing using DT1 cultivar in terms of their organoleptic and biochemical properties. Oolong tea samples produced with an identified processing combination showed more similarities to the reference sample obtained from China in terms of organoleptic and biochemical properties. Therefore, Sri Lankan artisanal tea producers could employ these processing conditions to produce high quality Oolong tea with typical characteristics present in the DT 1 cultivar.

Keywords: *Indoor withering, Oolong tea, sensory characteristics, solar withering, theaflavin, thearubigin*

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Drum-Type Scenting Machine for Jasmine Tea: Design and Performance Evaluation

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Abstract

The scenting process of tea with jasmine is central to jasmine tea production, as it directly determines the quality of the finished product. However, the traditional scenting process has poor sanitary conditions, high labor involvement and low heat dissipation efficiency, which seriously affects the quality of finished-jasmine tea. In order to solve these problems, a drum-type jasmine tea scenting machine was designed, and its geometric model was constructed based on SolidWorks three-dimensional design software, combined with discrete element numerical simulation software Rocky DEM and finite element analysis software ANSYS. The scenting process was simulated and analyzed, focusing on the blowing wind speed and duct size along with the optimization of key parameters such as drum speed. The results showed that the new scenting machine has significant advantages over the traditional scenting process in improving the quality and processing efficiency of the final product, Jasmin scented tea.

Keywords: *Gas-solid coupling, jasmine tea scenting machine, mechanical design, parameter optimization, performance testing*

Post-Harvest UV-B Radiation Improves Flavor Quality of White and Green Teas

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Abstract

It has long been known that sunlight contributes to the formation of tea aroma, but research on light exposure during postharvest processing and its impact on the flavor characteristics of tea has been limited. This study aims to investigate the effects of ultraviolet-B (UV-B) radiation provided through artificial lighting on the flavor of white tea and green tea, as well as its potential to improve tea flavor quality during postharvest processing. Sensory evaluation revealed that UV-B enhanced the aroma and taste of both types of tea, though it slightly affected the color and brightness of the tea infusion. Quantitative analysis of volatile compounds showed that UV-B significantly increased the level of floral and fruity volatiles; specifically, 1-pentanol, (*E*)-geranylacetone, methyl hexanoate, benzyl alcohol, and *β*-ionone increased by 84%, 73%, 79%, 68%, and 71%, respectively, while reducing the content of volatiles with fatty and smoky odors *i.e.* methyl salicylate and *N*-ethylpyrrole decreased by 36% and 26%, respectively. Additionally, UV-B had no significant effect on the concentrations of key taste-related secondary metabolites in green tea, such as total flavonoids, catechins, theanine, and caffeine. However, a significant increase in caffeine and a significant decrease in theanine were observed in white tea. These findings highlight the potential of using UV-B radiation to enhance the flavor profile of tea during postharvest processing, offering broad application prospects to produce high-grade quality teas.

Keywords: *Aroma, artificial lighting, taste, GC-MS, tea processing*

Heat Driven *β*-Lactoglobulin-Theaflavin Covalent Conjugates Exhibited Superior Antioxidant Potential and *In-vitro* Digestion Properties

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Abstract

This work investigated the structural and functional consequences of covalent conjugation between β-lactoglobulin (β-LG) and theaflavins (TFs) induced under thermal conditions. Model systems were prepared at various molar ratios and subjected to antioxidant assessment and simulated gastrointestinal digestion. Radical scavenging assays (ABTS and DPPH) revealed that β-LG-TF conjugates displayed markedly improved activity compared with free TF, with the greatest enhancement observed for complexes formed at 90 °C. Heat treatment promoted protein unfolding and facilitated covalent attachment, thereby increasing the accessibility of antioxidant moieties. In vitro digestion experiments further demonstrated that conjugation significantly altered proteolysis kinetics. During the gastric phase, β-LG-TF complexes exhibited higher hydrolysis rates than native or solely heated β-LG, suggesting that TF binding enhanced pepsin susceptibility. In the intestinal phase, the 90 °C β-LG-TF conjugates achieved the highest overall digestibility (~74% at 120 min), compared with ~61% for heated β-LG alone, indicating that structural modification and polyphenol incorporation synergistically promoted enzymatic breakdown. Collectively, these findings highlight protein–polyphenol conjugation as a promising strategy to simultaneously improve radical quenching capacity and digestive behavior of dairy proteins. Such conjugates may provide dual benefits as functional food ingredients, improving both stability of phenolic compounds and the nutritional value of carrier proteins.

Keywords: *Antioxidant, β-Lactoglobulin, covalent conjugate, in vitro digestion, theaflavin*

Sensomics-Assisted Characterization of Key Flowery Aroma Compounds in *Lu'an Guapian* Green Tea Infusion and Their Dynamic Changes during Processing

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Abstract

Lu'an Guapian (LAGP) is among the top ten green teas in China due to its unique flavor. As for the traditional manual manufacturing process, including spreading, pan-firing, and shaping, several baking steps (first baking, second baking, and deep baking) were conducted by two specialized workers. To improve and stabilize the quality of LAGP, the flavor code of Lu'an Guapian and further insight into the dynamic changes in odorants during the whole processing is required. Thus, the volatile fraction was isolated from the premium and common grade of *Lu'an Guapian* green tea (LAGP) infusion by solvent-assisted flavor evaporation distillation. With the application of aroma extract dilution analysis, a total of 52 aroma-active compounds were discovered in the flavor dilution (FD) factor area of 32-8192. The recombination experiment and the omission test of PGP clarified that 14 odorants constitute the aroma of LAGP. Among them, (*E*)-*β*-ionone, geraniol, and (*E*,*E*)-2,4-heptadienal, contributed to the flowery attribute most, which was determined as the critical factor of the difference between the two grades. To better understand the formation and accumulation of key odorants in LAGP tea, samples were collected from five processing stages (spreading, fixing, rolling, preliminary drying, and deep baking) and analyzed using sensomics-based approaches. The results revealed that the spreading plays a critical role in the development of key aroma compounds, which undergo substantial transformations during the deep baking stage. Notably, low-temperature spreading (4 °C for 6 hours) combined with low-temperature, extended-time baking (final leaf temperature: 102 °C for 45 minutes) significantly enhanced the overall aroma quality. These findings offer new insights into optimizing processing conditions to improve the quality of LAGP tea.

Keywords*: Aroma, flowery odor, green tea, Lu'an Guapian, processing*

Assessing the Effectiveness of the Public-Private Producer Partnership and Society (4PS) Oriented Model in Enhancing the Level of Adoption of Good Agricultural Practices (GAPs) of Tea Smallholders: A Case Study in Ratnapura District

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Abstract

This study assesses the effectiveness of the Public-Private Producer and Society Partnership (4PS) model in promoting Good Agricultural Practices (GAPs**)** among tea smallholders in Ratnapura, Sri Lanka. A sample of 100 tea smallholders from five villages in Niralgama, Kehelowitigama, Pelwadiya, Devipahala, and Galathura was recruited for the study using a cluster sampling approach. The data were collected through a survey using pre-tested questionnaires, focus group discussions, and interviews, focusing on access to resources, participation in training, extension services, satisfaction with the model, and adherence to Good Agricultural Practices. The findings show that the 4PS society-based extension model is effective, with 78 % of respondents achieving high adoption levels. However, 20% reported moderate adoption, indicating areas for improvement. While there are no low adoption levels, only 2 % reached very high adoption. Ordinal logistic regression indicated that the adoption of Good Agricultural Practices, such as harvesting practices and pruning practices ($p < 0.01$), as well as the degree of partnership ($p < 0.05$), had a significant effect on the overall adoption of GAPs. Additionally, the level of education had a positive and significant influence on effectiveness ($p < 0.05$). Key issues were identified as resource constraints, inadequate labor training, limited planting materials, and vulnerability to extreme weather. The 4P model encourages collaboration among stakeholders, contributing to technical assistance and sustainability, but requires more training programs and resources to fill the gaps. Recommendations include improving extension services, enhancing educational programs, and revisiting resource distribution and participation at community meetings to increase farmer engagement and participation. Improvements in these areas would improve land productivity, enhance the resilience and livelihoods of small holders, and support the sustainable growth of the tea sector and economic development in Sri Lanka.

Keywords: *Extension services, farmer satisfaction, public-private producer and society partnership, sustainable agriculture, tea smallholding sector*

Tea Plant Nursery Certification in Sri Lanka: Current Challenges and Way Forward

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Abstract

Sri Lanka's tea industry, a vital component of the national economy, faces significant challenges that threaten its long-term sustainability, including aging tea bushes, reduced cultivation areas, labor shortage, and environmental stresses. These issues, compounded by rising production costs, pest damages, and climate change impacts, have led to declining productivity and quality in the sector. To address these challenges, the Sri Lankan government has introduced various initiatives, including subsidies, replanting programs, and improvements in nursery management practices. However, a critical shortage of high-quality planting material for tea replanting still continues hindering industry growth. In response, strategic measures have been implemented, such as expanding mother bush areas and improving nursery certification processes. The Ministry of Plantation and Community Infrastructure, in collaboration with the Department of Agriculture, has introduced a strengthened tea nursery certification programme aligned with the Seed Act No. 22 of 2003. This initiative aims to register and regulate all commercial nurseries, ensure certified mother plant sources, and enforce quality labeling standards. The programme's objectives include improving nursery management, ensuring a steady supply of quality planting material, and uplifting planters' livelihoods through sustainable practices. This review explores the ongoing efforts to address these challenges, focusing on the importance of nursery management, regulatory frameworks, and the integration of sustainable practices to secure the future of Sri Lanka's tea sector. Its core functions are problem identification, action planning, awareness campaigns, progress reporting, resource utilization, and monitoring and thereby, creating a comprehensive framework for implementation. By aligning these initiatives with national goals for economic and environmental sustainability, Sri Lanka aims to revitalize its tea industry and strengthen its position in the global market.

Keywords: *Certification, challenges, regulatory framework, nursery management, tea*

Performance Evaluation of Batch-Type Electric Dryer for Artisanal Tea Production in Sri Lanka

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Abstract

Artisanal tea, also known as specialty tea, is an emerging segment in Sri Lanka's tea industry. Drying is crucial for ensuring quality, shelf life and marketability of produced tea. The producers often rely on inefficient and inconsistent methods due to a lack of access to suitable technology. A batch-type electric tea dryer with a capacity of 5-10 kg green leaf has been developed by the Tea Research Institute of Sri Lanka. The dryer incorporates features such as energy efficiency, controlled temperature and airflow, air recirculation, and monitoring of inlet and exhaust air temperatures. This study evaluated the performance of the dryer under varying operational conditions by altering the dryer loading capacity and drying air temperatures. Drying tea at 70 °C and operating the dryer at 50 % capacity or higher recorded lower specific electricity consumption. However, drying at temperatures of 90 °C and 110 °C demanded operating at 75% capacity or above for energy efficiency. At this operating condition, the average specific electricity consumption for drying artisanal tea was 12 kWh/ kg tea. Chemical analysis of the dried artisanal tea samples revealed that drying tea at 70 °C promoted post -chemical reactions, resulting in higher levels of theaflavin and thearubigins, whereas drying at the higher temperatures at 90 °C and 110 °C led to an early arrest of fermentation reactions.

Keywords: *Artisanal tea, batch-type electric tea dryer, drying air temperature, loading capacity*

Multi Tray Self Cleaning Sifter for Grading Low Grown Teas

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Abstract

The grading process in Low grown black tea manufacture primarily relies on Michie oscillatory sifters fitted with various size meshes. Clogging of tea particles on the meshes during sifting is a common issue in said sifters. A Multi-Tray Self-Cleaning Sifter comprising of No.4, 6, and 8 meshes with self-cleaning mechanism introduced by the Tea Research Institute of Sri Lanka has been developed to replace three Michie oscillatory sifters having same mesh combination. Sifting of tea is improved with hardly any clogging of tea particles on the meshes. The average throughput of the developed sifter was 142.52 kg /hr which is significantly higher than that of the selected three Michie oscillatory sifters. The through put of the three Michie oscillatory sifters was 46.15 kg/hr. As a result, the worker productivity increased from 9.32 to 142.5 kg/worker/hr. Average worker requirement for operating the developed sifter is one compared to the selected three Michie oscillatory sifters which required five workers. Considering the present wages, saving on daily operational cost is found to be LKR 6,210. Further, the use of the developed sifter resulted in increase in the main grades by 4.73%. Due to this, the overall net sale average of tea increased by 16.50 LKR/kg.

Keywords: *Michie Oscillatory sifter, multi-tray self-cleaning sifter, net selling average, pure orthodox black tea*

Effect of Nursery Bed-type for Tea (*Camellia sinensis* (L) O. Kuntze) Nursery Plants in Low Altitude Regions of Sri Lanka

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Abstract

Nursery management is an important practice for tea cultivation to establish healthy, vigorous plants. The low-altitude areas receive excessive rains throughout the nursery period leading to developing unfavorable soil moisture conditions around the root zone in the nursery bag, which impacts plant growth. The experiment was designed to evaluate four different nursery bed types: soil raised bed (SRB), wooden pellet bed (WPB), sloping raised bed (SLB) covered by polythene, and raised bed prepared from stones (StB). Bagged nursery plants were placed on the four different nursery beds. The SRB showed a significantly low soil moisture percentage (18.3%–20.3%) in the root zone of the nursery bag compared to SLB (22.2%–26.9%), StB (19.2%–23.4%) and WPB (22.7% - 26.6%). The survival rate, shoot height, leaf area, and shoot and root dry matter percentages of plants were significantly higher in SRB. Root lengths of plants were significantly highest in StB. Brown blight disease was significantly lower in SLB and root rotting disease was significantly lower in SRB. According to the results, maintaining tea nursery plants on the SRB was more favorable for plant survival and growth and allowed them to avoid water logging conditions around the root zone of the nursery bags during the nursery period.

Keywords: *Growth, nursery bed, rainfall, soil moisture, water logging*

Blister Blight Control in Tea Using Nano Copper Sulphate Pentahydrate

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Abstract

Blister blight (BB), caused by *Exobasidium vexans* Massee, is a major foliar disease of tea resulting in 20–50% crop loss during the monsoon period. Copper fungicides have been recommended as protective fungicides for managing BB. Currently, formulations such as copper hydroxide, copper sulphate, and copper oxide containing 20-50% metallic copper are widely used in tea fields in Sri Lanka. Nano copper fungicides have gained particular interest owing to their reduced application rates, and lower environmental impact. The present study was conducted to evaluate the bio efficacy of nano copper sulphate pentahydrate (5.2% w/w metallic copper) and to determine its residue levels in made tea. Field trials were conducted using a Randomized Complete Block Design (RCBD). Different concentrations of nano copper sulphate pentahydrate (0.05%, 0.1%, 0.2%, and 0.3%) were compared with the recommended copper hydroxide WG and an untreated control. Declining residue trial was conducted as per guided protocols of FAO and Organization for Economic Co-operation and Development. Disease severity in terms of Area Under Disease Progress Curve (AUDPC) were significantly lower in the plots treated with nano copper and standard copper hydroxide fungicides ($p<0.05$) compared to the untreated control. Among the nano copper treatments, the lowest disease severity was recorded in 0.3% concentration, which is comparable to the disease severity observed with 0.1% copper hydroxide treatment. Copper residue in made tea treated with 0.3% nano copper was lower than 40 ppm (the Maximum Residue Limit allowed by European Union). Considering comparable efficacy with recommended copper hydroxide fungicide and lower residue levels in made tea, nano copper sulphate pentahydrate can be a potential addition for integrated blister blight management in tea.

Keywords: *AUDPC, Exobasidium vexans, Fungicide, Nano copper*

Acknowledgement: *This work was financially supported by Tea Research Institute of Sri Lanka and JAT Agri (Pvt) Ltd.*

Efficacy of Combined Applications of Chlorantraniliprole 0.4% GR and *Metarhizium* sp. against White Grubs in Tea Plantations

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Abstract

White grubs are the larvae of Scarabaeid beetles (Coleoptera: Scarabaeidae). Two species, *Holotrichia disparilis* and *Microtrichia costata*, which cause significant root damage in immature tea. This study evaluated the efficacy of chlorantraniliprole 0.4% GR, *Metarhizium* sp., against white grubs and compatibility of the entomopathogenic fungus *Metarhizium* sp. with the insecticide Chlorantraniliprole 0.4% GR, and their combination against white grub infestations. Chlorantraniliprole, a novel anthranilic diamide insecticide effective against Lepidoptera and Coleoptera, was tested at three dosage levels (10, 20, and 30 g per plant) and compared with the currently recommended formulation 200 g/L SC (200 ml/plant of 0.1% solution) and untreated control. *Metarhizium* sp. efficacy was assessed at 14, 21, and 28 days after treatment (DAT). Poisoned culture assay was conducted to determine Chlorantraniliprole's impact on *Metarhizium* growth. Pot trial was conducted using half (10 g) of the recommended Chlorantraniliprole 0.4% GR dose with 40 g of *Metarhizium* to evaluate potential combined effects. Results revealed 46.9±6.0 % mortality by *Metarhizium* alone, at 28 DAT. Chlorantraniliprole 0.4% GR 20 g/plant provided 80±11.5% mortality at 28 DAT, there were no significant differences among 20 g, 30 g per plant, and 200 g/L SC current recommendation. Poisoned culture assays demonstrated no inhibition of *Metarhizium* by Chlorantraniliprole 0.4% GR, indicating compatibility. The combined treatment showed significantly enhanced 88.3±3.1% grub mortality at 21 DAT. Integrating half-dose Chlorantraniliprole (10 g) with *Metarhizium* (40 g) offers an effective and sustainable white grub management strategy in tea plantations, achieving improved pest control while reducing chemical inputs. This approach supports environmentally sound and economically viable tea cultivation.

Keywords*: Bio-efficacy, Chlorantraniliprole, Combination effect, IPM, Tea, Metarhizium* sp., *White grubs*

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