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"Smart Agriculture for a Resilient Future: Bridging Climate Adaptation and Global Opportunities"

ISATRS 2026



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MESSAGE FROM THE VICE-CHANCELLOR

I am pleased to extend my warm wishes for the International Symposium on Agro-Technology and Rural Sciences (ISATRS 2026), organized by the University of Colombo Institute for Agro-Technology and Rural Sciences (UCIARS). The theme of this year's symposium, "Smart Agriculture for a Resilient Future: Bridging Climate Adaptation and Global Opportunities" is both timely and highly significant, as it reflects global and national priorities in achieving food security, strengthening climate resilience, and promoting sustainable agricultural development. This symposium marks an important milestone for UCIARS as it evolves from a successful national platform into an internationally recognized forum for academic and professional engagement. By bringing together researchers, innovators, entrepreneurs, farmers, policymakers, and industry leaders, ISATRS 2026 provides a valuable opportunity for collaborative dialogue and the exchange of knowledge, technologies, and best practices that are essential for transforming the agricultural sector in a rapidly changing world.



I deeply appreciate the dedicated efforts of the Director, academic and administrative staff, and students of UCIARS in organizing this prestigious international event. Your unwavering commitment to excellence, even amidst numerous challenges, reflects the strength, resilience, and vision of the institute. UCIARS has consistently demonstrated its role as a center of excellence in Agro-Technology by nurturing highly skilled graduates while contributing significantly to research, innovation, and sustainable agricultural advancement. The University of Colombo takes great pride in the remarkable achievements of UCIARS and its vital contribution toward advancing climate-smart agriculture in Sri Lanka and beyond. I commend your collective efforts in making ISATRS 2026 a reality and wish the symposium every success as it sets a new benchmark for international academic and research collaboration.

Professor I.M. Karunathilaka
Vice Chancellor
University of Colombo
Sri Lanka

MESSAGE FROM THE DIRECTOR

It is with great pride and enthusiasm that I deliver this message as the Director of the University of Colombo Institute for Agro Technology and Rural Sciences (UCIARS), on the occasion of the International Symposium on Agro Technology and Rural Sciences (ISATRS 2026). Following the success of our transition to the international stage, this year's symposium is driven by a highly vital and forward-looking theme: "Smart Agriculture for a Resilient Future: Bridging Climate Adaptation and Global Opportunities".



A midst intensifying global climate challenges, shifting socioeconomic landscapes, and the pressing need to secure global food supply chains, building agricultural resilience has become an absolute priority. Traditional farming practices face unprecedented pressures, making the integration of smart agricultural technologies essential. Today, our focus must extend beyond immediate survival; we must actively bridge the gap between localized climate adaptation and the vast global opportunities that emerging technologies and international markets offer.

Building upon our international foundation, ISATRS 2026 serves as a crucial nexus for researchers, academics, industry practitioners, and policymakers from around the globe. This platform continues to foster deep cross-border collaboration, invite diverse perspectives, and stimulate cutting-edge dialogue on sustainable rural development and tech-driven agricultural solutions.

ISATRS 2026 remains steadfastly committed to empowering the next generation of change makers. By providing young academics, researchers, and students with a vibrant forum to showcase their research and engage with global thought leaders, we ensure the continuity of innovation. UCIARS continues to champion its core mission: facilitating knowledge sharing, technology transfer, product innovation, and nurturing the agro-entrepreneurial talent vital to the agricultural advancement of Sri Lanka and the global community.

I would like to extend my heartfelt appreciation to the organizing committee, our distinguished keynote speakers, local and international presenters, and all participants for their invaluable contributions and commitment. I wish ISATRS 2026 resounding success and look forward to the collaborative energy and transformative ideas this symposium will ignite across borders and disciplines.

Prof. D.M.C.C. Gunathilake
Director / UCIARS

MESSAGE FROM THE CHAIRPERSON

It is with immense honor and privilege that I convey this message on the occasion of the International Symposium on Agro Technology and Rural Sciences 2026 (ISATRS 2026), organized under the theme “Smart Agriculture for a Resilient Future: Bridging Climate Adaptation and Global Opportunities”.



This symposium serves as a distinguished platform to present and deliberate upon the research conducted in the field of Agro-Technology over the years. The principal objective of organizing this symposium is to disseminate research findings, promote technological innovations, and formulate future research directions aimed at enhancing agricultural productivity in response to both national and global demands. The diversity of specializations and thematic areas represented at this symposium will undoubtedly contribute toward achieving our institutional vision and mandate.

The commitment, dedication, and tireless efforts extended by the members of the organizing, scientific, technical, and financial committees in preparing for this event are sincerely appreciated. Their invaluable contributions have been instrumental in making this symposium a reality. I also extend my sincere appreciation to the academic reviewers for their professional, timely, and constructive evaluation of the submitted papers.

On behalf of the organizing committee, I wish to express my profound gratitude to the Chief Guest of the event, Professor Indika Mahesh Karunathilake, Vice Chancellor of University of Colombo; the Guest of Honor, Mr Harvinder Singh, Consul General of India, Hambantota, Sri Lanka; the Director of University of Colombo Institute for Agro-Technology and Rural Sciences, Professor D.M.C.C. Gunathilake; and the keynote speakers, Kazuhito Sakai, Professor, Department of Regional Agricultural Engineering, Faculty of Agriculture, University of the Ryukyus, Japan, and Thiagarajah Ramilan, Associate Professor, School of Agriculture and Environment, Massey University, New Zealand, for graciously accepting our invitation and enriching this symposium with their presence and expertise.

Above all, I extend my sincere gratitude to all presenters and participants whose valuable contributions and active participation have greatly enriched this symposium. I congratulate the organizing committee of ISATRS 2026 and sincerely wish the symposium every success.

Prof (Ms.) N.P. Vidanapathirana
Symposium Chair / ISATRS 2026

MESSAGE FROM THE COORDINATOR

It is a great honor and privilege to welcome you to the International Symposium on Agro-Technology and Rural Sciences (ISATRS 2026). This symposium serves as an important forum for bringing together researchers, academics, practitioners, and policymakers to share their knowledge, experiences, and innovations that contribute to the advancement of agriculture and rural development through the theme “Smart Agriculture for a Resilient Future: Bridging Climate Adaptation and Global opportunities”.



The collection of papers included in these proceedings represents a diverse range of research findings, innovative technologies, and practical solutions that address contemporary challenges in agro-technology and rural sciences. The quality and diversity of the contributions demonstrate the growing commitment of the scientific community to promoting sustainable agricultural development and improving rural livelihoods.

I would like to express my sincere appreciation to all authors for their valuable contributions and to the reviewers for their dedication in maintaining the academic quality of the symposium. My gratitude is also extended to the keynote speakers, session chairs, organizing committee members, sponsors, and all participants whose support and commitment have made this event possible.

We trust that these proceedings will provide a valuable resource for researchers, educators, students, and practitioners, fostering future collaborations and inspiring further research in the field.

Thank you for being a part of this important academic gathering, and I wish you a productive and rewarding experience.

Ms. S.L. Nawarathna
Symposium Coordinator / ISATRS 2026

MESSAGE FROM THE SECRETARY

It is with great pleasure that I share my message for the International Symposium on Agro-Technology and Rural Sciences (ISATRS) 2026, organized by the University of Colombo Institute for Agro-Technology and Rural Sciences (UCIARS). The theme of this year's symposium, "Smart Agriculture for a Resilient Future: Bridging Climate Adaptation and Global Opportunities" underscores the critical role of innovation, technology, and collaboration in addressing the challenges facing modern agriculture.



It is a privilege to serve as the Symposium Secretary of ISATRS 2026. I firmly believe that research and innovation are fundamental drivers of agricultural transformation. The integration of smart technologies with scientific knowledge and practical farming solutions can significantly enhance productivity, resource-use efficiency, and climate resilience. Equally important are the strong partnerships among researchers, educators, industry stakeholders, policymakers, and farming communities, which are essential for translating scientific discoveries into meaningful and sustainable outcomes. The research findings presented in these proceedings reflect the dedication and commitment of scholars and professionals working to advance knowledge in agro-technology and rural sciences. Their contributions not only enrich academic understanding but also provide valuable insights and practical solutions to the challenges confronting agriculture and rural development at local, regional, and global levels.

I extend my sincere appreciation to all authors, reviewers, keynote speakers, session chairs, sponsors, and members of the organizing committee whose hard work, expertise, and unwavering support have contributed to the success of this symposium. Their collective efforts have created a valuable platform for knowledge sharing, networking, and collaboration. I am confident that the ideas and discoveries presented through ISATRS 2026 will inspire further research, foster interdisciplinary partnerships, and contribute to the development of innovative solutions for a more resilient and sustainable agricultural future.

I wish every success to ISATRS 2026 and trust this proceedings will serve as a valuable resource for researchers, practitioners, policymakers, and students alike.

Ms. K.G. Ketipearachchi
Symposium Secretary / ISATRS 2026

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**SMART AND CLIMATE-READY CROP
PRODUCTION TECHNOLOGIES**

PERFORMANCE EVALUATION OF PROMISING RICE VARIETIES IN DIFFERENT FERTILITY CONDITIONS OF THE LOW COUNTRY WET ZONE

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Abstract

Sri Lanka's Low Country Wet Zones (LCWZ) make a considerable contribution to national rice production, but several factors have constrained productivity in this zone. Iron toxicity, nutrient imbalance, poor drainage, soil acidity, low organic residue decomposition rates, and the growing of rice varieties that are not well adapted to LCWZ conditions have limited the yield potential. Therefore, this study was carried out to evaluate the performance of promising rice cultivars under different fertility levels in a long-term research field at the Rice Research Station, Labuduwa, to identify the most suitable cultivars for sustainable cultivation in the LCWZ (Yala 2025). The trial plot was established in four plots (9 m × 8 m) and conducted in a nested design with two replications and four fertility treatments, T1 – no fertilizer (control), T2 – recommended inorganic fertilizer only, T3 – combined organic and inorganic fertilizer, and T4 – organic fertilizer only. Each treatment included ten promising rice varieties, Ld S2b7, Ld 365, Ld 371, Bw 372, At 313, Ld 368, Ld 408, Ld 376, Bw 367, and At 362 were tested. Data were analyzed using SAS software, and mean separation was accomplished by Duncan's Multiple Range Test (DMRT) at a 5% significance level. Results revealed significant differences ($p < 0.05$) among treatments and varieties for growth and yield characteristics such as plant height, tiller number, panicle characteristics, 1000-grain weight, root and shoot biomass, and total seed weight. Variety Ld 376 under the chemical fertilizer treatment possessed the tallest plant height, stem dry weight, and total seed weight, while variety At 313 had comparatively lower values. Soil analysis after crop harvesting showed enhancement in pH, organic matter and available phosphorus under T3 specifically. Overall, the combination of high-yielding varieties such as Ld 376, Bw 367, and At 362 with T2 and T3 fertility management improved soil health and crop performance, while Ld 376 under T2 and T3 recorded the highest total seed weight, indicating superior yield performance.

Keywords: Fertilizer, LCWZ, Rice, Soil, Yield

FRUIT QUALITY OF FIELD GROWN TOMATO AS AFFECTED BY SUSTAINABLE AGRONOMIC PRACTICES; A CASE STUDY IN MATALE DISTRICT, SRI LANKA

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Abstract

Tomato (*Solanum lycopersicum*) is a common and popular vegetable worldwide; however, limited field-based investigations on how sustainable farming practices affect fruit quality in the Sri Lankan context. Therefore, the study aimed to evaluate the effects of preharvest agronomic practices, including bed types, plant spacing, irrigation methods and intervals, mulching, pruning, and fertilizer management on tomato fruit quality cultivated under open-field conditions in Sri Lanka. A cross-sectional survey was conducted using a structured questionnaire with the participation of 40 tomato farmers from Naula and Dambulla Agrarian Service Divisions in Matale District, selected based on a stratified random sampling method. Additionally, 10 mature fruits from each farm were assessed for quality parameters, including Chroma value, firmness, total soluble solids (TSS), titratable acidity (TA), juice pH, physiological disorders, physiological weight loss, and shelf life. Data were analyzed using ANOVA, General Linear Model (GLM), and Two-way ANOVA. The results revealed that irrigation interval, pruning methods, mulching, plant spacing, nutrient management, and farming system significantly affected several fruit quality attributes ($p < 0.05$). Organic fertilizer use, boron application, and foliar fertilization reduced physiological disorders, especially blossom-end rot. Tomato variety and plant spacing significantly influenced TSS, while irrigation and pruning improved fruit coloration through enhanced light exposure and carotenoid synthesis. However, juice pH, physiological weight loss, and shelf life were not significantly affected by the agronomic practices studied. Overall, the findings highlight the importance of adopting suitable preharvest agronomic practices to enhance tomato fruit quality and support sustainable tomato production in Sri Lanka.

Keywords: Agronomic, Fruit quality, Pre-harvest practices, Tomato, Sri Lanka

A BIOFILM MICROBIAL AMELIORATOR FOR LEAF LITTER DECOMPOSITION

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Abstract

Decomposition of leaf litter is an important ecological process that affects soil fertility and nutrient cycling, but it frequently occurs slowly because of resistant substances like lignocelluloses. Naturally, the decomposition of complex organic matter is accelerated by litter-attached microbial biofilms, which are organized communities of bacteria, fungi etc. embedded in a polysaccharide matrix. The ability of a developed Biofilm Microbial Ameliorator (BMA) to improve the litter decomposition and composting of fast and slowly degrading leaf litters, i.e., *Gliricidia sepium* (Gliricidia) and *Mangifera indica* (Mango), respectively, as well as their mixtures in different ratios, was examined in this study. Litter samples underwent four weeks of controlled laboratory treatments with either water or BMA after being air- and oven-dried (40 °C), and ground to 0.5 mm. Decomposition rates were quantified by percentage weight loss. Changes in biochemical composition (cellulose, hemicellulose, lignin, and functional groups) and microbial biomass indicators (biofilm, fungi, bacteria) were monitored using ATR-FTIR spectroscopy as a complementary non-destructive technique. Carbon (C), Nitrogen (N) and C/N ratios were primarily determined by CHN analysis, while FTIR provided supporting insights into compositional shifts for litters with only C/N ratios ≤ 20 . Five litter mixtures were initially tested, but only three met the reliable FTIR calibration range. This reduction limited statistical power and is a major limitation. BMA notably increased weight loss in the 1:3 Gliricidia: Mango ratio, reduced cellulose- and hemicellulose-related features, microbial biomass, and total carbon, and produced lower C/N ratios, indicating higher-quality compost. As a pilot study, these findings highlight the value of integrating FTIR spectroscopy with elemental analysis. This is the first FTIR-based evaluation of leaf litter decomposition in Sri Lanka.

Keywords: Decomposition, FTIR spectroscopy, Leaf litter, Microbial biofilms, Nutrient cycling

EVALUATING OF MICRO AGROFORESTRY SYSTEMS AS COMMUNITY-BASED CARBON SINKS IN THE BUNDALA NATIONAL PARK BUFFER ZONE, SRI LANKA

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Abstract

Climate change, land degradation, and increasing pressure on protected areas present significant challenges to ecosystems and the livelihoods of communities living in buffer zones of national parks. This study investigates the establishment of micro agroforestry systems as community-based carbon sinks in the buffer zone of Bundala National Park, a Ramsar wetland site in Sri Lanka. The project aimed to enhance climate-resilient land management while increasing carbon sequestration, improving household food security, and promoting sustainable resource use. The initiative was implemented through the establishment of twenty micro agroforestry plots (10 m × 10 m) in selected household gardens within the Bundala buffer zone. Households were selected through community consultations based on land availability and willingness to participate. Participants received training in carbon-smart agriculture, composting, and sustainable land management practices, along with planting kits comprising fruit trees (Mango, Guava, Banana, Pomegranate), multipurpose trees (Moringa, Neem, Gliricidia), and vegetable and cover crops. Water-efficient drip irrigation systems were introduced to address low rainfall and water scarcity. The agroforestry systems integrated fruit trees, medium-sized trees, vegetable crops, and ground cover species, contributing to above-ground biomass accumulation and improved soil carbon storage. Estimated carbon sequestration ranged between 3,200 and 6,000 kg CO₂ annually per 20 plots, excluding additional gains from soil carbon enhancement through compost application and vegetation cover. Beyond carbon sequestration, the project generated multiple co-benefits, including improved household food production, reduced organic waste through composting, enhanced water-use efficiency, and increased ecological connectivity within the buffer landscape. Community engagement and training programs strengthened local awareness of climate adaptation and sustainable land-use practices. The findings suggest that micro agroforestry systems represent a scalable, community-driven approach to climate mitigation and adaptation in protected area buffer zones. This model provides an integrated framework for achieving biodiversity conservation, carbon sequestration, and livelihood enhancement, with strong potential for replication in similar dry-zone ecosystems.

Keywords: Agroforestry, Bundala buffer zone, Carbon sequestration, Climate adaptation, Community-based conservation

EVALUATION OF GROWTH AND YIELD PERFORMANCES OF SELECTED SHORT DURATION RICE (*Oryza sativa* L.) VARIETIES IN THE LOW COUNTRY INTERMEDIATE ZONE DURING *Yala* 2025

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Abstract

Rice (*Oryza sativa* L.) is the staple food crop in Sri Lanka, and improving the productivity of short-duration varieties is vital to sustaining rice cultivation under the fluctuating climatic conditions of the Low Country Intermediate Zone (LCIZ). This study was conducted at the Rice Research and Development Institute (RRDI), Bathalagoda, during the *Yala* 2025 season to evaluate growth and yield performances of four control short-duration rice varieties (Bg 300, Bg 304, At 306, and At 308) and eight progeny lines under field conditions. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicates. Management practices were followed according to the Department of Agriculture recommendations. Results revealed that differences ($p < 0.05$) were found among key agronomic traits, yield components, grain quality parameters, and pest incidence. Measured variables included plant height, tiller number per hill, flag leaf length and width, days to 50% flowering, days to maturity, panicle number per hill, white-head percentage, grain shape and color, seed moisture, and grain yield. Based on substantial genotypic variation was observed, with 24-1733, 24-1704 and 24-1746 identified as the most promising high-yielding and adaptable breeding lines for LCIZ conditions. These findings provide valuable insights for future breeding programs and selection aimed at enhancing rice productivity and resilience of short-age rice cultivars in Sri Lanka.

Keywords: Growth performances, LCIZ *Yala*, Short age varieties, Yield performances

APPLICATION OF PADDY HUSK ASH AND GARLIC EXTRACT FOR SUSTAINABLE PEST AND DISEASE MANAGEMENT IN PAK CHOI CULTIVATION

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Abstract

Pak Choi (*Brassica rapa* subsp. *chinensis*) is a fast-growing leafy vegetable that is highly susceptible to pest and disease damage, which can significantly reduce marketable yield. Although chemical pesticides are used in conventional management, increasing environmental and concerns have driven interest in ecofriendly alternatives health. Therefore, this study evaluated the effectiveness of garlic extract and paddy husk ash extract, applied individually and in combination, for managing pest and disease management in Pak Choi variety ‘*Chie itaya*’, grown at Alex DIMO Agri Techno Park, Lindula, Talawakelle. The experiment consisted of seven treatments: T1 (control) (no application), T2 (chemical pesticides), T3 (paddy husk ash extracts only), T4 (garlic extract only), T5 (50% paddy husk ash extract +50% garlic extract, T6 (75% paddy husk ash extract + 25% garlic extract), and T7 (25% paddy husk ash extract + 75% garlic extract). The experiment consisted of 28 plots divided into 7 treatment groups, each replicated 4 times. The randomization process ensured unbiased distribution of treatments across the plots, following a randomized complete block design (RCBD). Data were collected on number of leaves per plant, damaged leaves per plant, leaf damage intensity damage intensity, fresh plant weight, damaged leaves and net plant weight at harvest. Indicated that significant results, treatment 6 (75% paddy husk ash extract + 25% garlic extract) consistently produced the highest number of leaves per plant, the highest fresh, and net plant weight also showed the lowest pest damage. While treatment 2 (chemical treatment pesticide) showed the lowest number of damaged leaves during growth stage whereas, treatment 4 (garlic extract only) recorded the lowest damaged leaves at harvest. Overall, the findings suggest that a combined application of paddy husk ash extract and garlic extract at a 75:25 ratio can serve as an effective alternative to chemical pesticides for pest control in Pak Choi cultivation, enhancing productivity while minimizing reliance on synthetic inputs.

Keywords: Garlic extract, Paddy husk ash extract, Pak Choi, Pest and disease management, Sustainable farming

FORMULATION OF NEW COMPLETE NUTRIENT SOLUTIONS ON PROTECTED AGRICULTURAL CROPS

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Abstract

Protected cultivation plays an important role in Sri Lanka for the production of high-value vegetables such as salad cucumber and bell pepper, as it enhances yield and product quality compared to open-field cultivation systems. However, the unmanaged discharge of nutrient drainage solutions may pose environmental risks and reduce the sustainability of protected cultivation. Therefore, there is a need to develop and validate scientifically optimized complete nutrient formulations for these crops. The main objective of this study was to develop and evaluate new complete nutrient formulations for optimizing the growth, yield, and quality of protected agricultural crops, particularly salad cucumber and bell pepper. The study was conducted at the Regional Agricultural Research Station, *Bandarawela*. Salad cucumber (*HanYan*) and bell pepper (*Indra*) varieties were selected due to their high economic value, yield potential, and adaptability to greenhouse conditions. The experiment was arranged in a Completely Randomized Design (CRD) with five treatments and three replications. The treatments consisted of Albert (T1), Kodimix (T2), Formula 1 (T3), Formula 2 (T4), and Formula 3 (T5), each representing a distinct nutrient formulation designed to evaluate its effectiveness on crop growth and yield under protected cultivation. Growth parameters measured included plant height, days to first flowering, and SPAD readings. Quality parameters included yield per plant, fruit length, fruit diameter, and total soluble solids (°Brix). Substrate pH and electrical conductivity (EC) were also monitored. Data were analyzed using Minitab Statistical Software. The results indicated that all formulated nutrient solutions, namely Kodimix (T2), Formula 1 (T3), Formula 2 (T4), and Formula 3 (T5), significantly improved plant height, reduced the number of days to first flowering, and enhanced total yield and fruit quality compared with the Albert solution (T1). Based on total yield, T2, T4, and T5 are recommended for salad cucumber production, whereas T2, T3, T4, and T5 are recommended for bell pepper production under protected cultivation. Further studies are required to validate these findings under different environmental and management conditions.

Keywords: Bell pepper, Nutrient, Protected agriculture, Salad cucumber, Solution

COMPOST AND UREA SYNERGY: BOOSTING TROPICAL MAIZE-SOYBEAN PRODUCTIVITY THROUGH CLIMATE-SMART AGRICULTURE

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Abstract

Intensification of crop production while minimizing environmental degradation remains a major challenge for smallholder agriculture in the tropics. Integrated soil fertility management, which combines organic and mineral nitrogen (N) amendments, has emerged as a promising climate-smart approach for maintaining productivity in degraded tropical soils. This study aimed to determine the impacts of combined compost and urea treatments on crop yield and nitrogen-use efficiency in a maize-soybean rotation in Matara Sri Lanka. A two factor factorial field experiment was conducted over two successive cropping cycles, including two compost rates (0 and 15 Mg ha⁻¹ dry weight) and four urea-based nitrogen rates (zero-N, low-N, medium-N and high-N). The medium-N rate was equivalent to the recommended rate (i.e., 150 kg N ha⁻¹) of the Department of Agriculture of Sri Lanka. The experiment was arranged in a completely randomized block design with four replications, resulting in eight treatment combinations. The combined use of compost and mineral N enhanced soybean above-ground biomass and total N accumulation compared to sole mineral N application particularly, at low and medium rates of N. Application of compost at the medium-N rate resulted in 71% and 39% significant increase ($p < 0.05$) in soybean total above-ground biomass and biomass N content, respectively, with productivity comparable to the sole high-N treatment. At low-N rate, corresponding improvements were 37% and 42 % respectively. However, the influence of compost was not significant in the high-N rate, indicating a saturation effect under high mineral nitrogen supply. The result indicated a strong synergistic correlation between the organic and inorganic N sources at moderate levels, which weakens at higher levels of mineral N. These findings suggest that incorporating locally produced compost with reduced amounts of mineral nitrogen is a feasible, cost-effective and climate smart approach to enhance crop yield, improve soil N cycling, and reduce reliance on synthetic fertilizer reliance in tropical agricultural systems, with significant implications for food security and agricultural sustainability.

Keywords: Above-ground biomass, Compost, Maize-soybean rotation, Tropical soil fertility, Urea

OPTIMIZING HEAT PRETREATMENT, TEMPERATURE AND SOAKING DURATION TO BREAK SEED DORMANCY AND TO ENHANCE GERMINATION OF *Oryza nivara*

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Abstract

Oryza nivara is the most common wild rice species in Sri Lanka, having an AA genome. Poor germination of *O. nivara* seeds associated with strong dormancy is a challenge in effectively using them as a genetic resource. The aim of the study is to identify the optimal temperature, oven time, and soaking duration for breaking the dormancy of *O. nivara* seeds. The experiment included 24 treatments with two temperatures (50°C and 60°C), four oven times (24 hr, 48 hr, 72 hr, and 96 hr), and three soaking durations (24 hr, 48 hr, and 72 hr). Initially, seeds were placed in an oven at two different temperatures for the specified oven times. Next, the seeds were dehusked and soaked for different time durations. The soaked seeds were then spread on wet tissue and incubated at 36°C. The experiment was conducted as a 2 × 4 × 3 factorial completely randomized design, with 10 seeds per replicate and three replicates per treatment. Germination data were recorded at two-day intervals, with a maximum germination observation time of 10 days. A highly significant three-way interaction among temperature, oven duration, and soaking duration was observed ($F(6,48) = 23.691$, $p < 0.001$, $\eta^2p = 0.748$), indicating that germination depends on their combined effects. All two-way interactions were also significant: temperature × oven duration ($F(3,48) = 57.321$, $p < 0.001$, $\eta^2p = 0.782$), temperature × soaking duration ($F(2,48) = 39.148$, $p < 0.001$, $\eta^2p = 0.620$), and oven duration × soaking duration ($F(6,48) = 14.062$, $p < 0.001$, $\eta^2p = 0.637$). The highest germination (90.0%) occurred at 50 °C, 24 hr oven duration, and 48 hr soaking. Overall, the three-way interaction effect showed that the best combination to achieve the highest seed germination rate was 50°C temperature, 24 hr oven duration, and 48 hr soaking period, yielding an impressive germination rate of 90.0% (± 3.536) over the rest of the variable combinations tested.

Keywords: Factorial design, Oven duration, Soaking duration, Thermal stratification, Wild rice

DEVELOPMENT OF A LOW-COST METHOD TO DIFFERENTIATE ORGANIC AND NON-ORGANIC *Centella asiatica* (GOTUKOLA)

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Abstract

Centella asiatica L., commonly known as Gotukola is an important leafy vegetable with several medicinal properties. It is commercially available as organic and non-organic leafy vegetables. However, people cannot distinguish between them, and there are no methods to verify whether they are truly organic. This study was conducted to develop a low-cost method to differentiate them based on characteristics of cultured microbes. Commercial organic and non-organic samples, as well as cultivated organic and chemically fertilized (conventionally grown) samples were collected and their leaves were used for bacterial extraction and cultured on Nutrient Agar (NA), Combined Carbon Medium (CCM), and Modified Combined Carbon Medium (MCCM) to observe bacterial colony morphology based on color, margin, and shape. The isolates were further streaked on plates, stained, and examined microscopically to determine cell morphology, and viability. The experiment was arranged in a Completely Randomized Design with three replicates for each treatment, especially for evaluating cell viability. The results revealed that the MCCM exhibited distinct differences in colony color between chemically fertilized and organic leaf samples, whereas NA and CCM did not show consistent variations. Streak plate observations indicated no significant morphological difference between the commercial organic and non-organic samples or between the cultivated organic and chemically fertilized treatment. Microscopic observations showed a higher microbial abundance in cultivated organic samples. Cell viability showed no statistically significant differences among the four treatments. The study demonstrated that MCCM could be a promising medium for preliminary differentiation of cultivation practices of *C. asiatica*. Further analyses, (molecular or biochemical) are recommended to enhance detection accuracy and confirm organic authenticity.

Keywords: *Centella asiatica*, Organic, Leafy vegetables

FEASIBILITY OF BIOFILM BIOFERTILIZER PRACTICES IN *Centella asiatica* CULTIVATION

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Abstract

Centella asiatica (L.) (CA; family Apiaceae) is a valuable medicinal herb and a green leafy vegetable. The demand for CA has increased significantly due to its important medicinal properties. However, excessive use of chemical fertilizers (CF) has resulted in reduced soil fertility and increased environmental pollution. Biofilm biofertilizer (BFBF) is a novel biotechnology that is applied in many crops to enhance soil fertility and productivity by reducing CF use by 50%. This study assessed the feasibility of BFBF application by examining its effects on soil nutrients, soil and plant microbiota, plant growth, and bioactive compound accumulation. A pot experiment was conducted under greenhouse conditions using two CA varieties in Completely Randomized Design with five treatments: 100% CF [recommended by Department of Agriculture (DOA)], 50% CF alone, 50% CF + BFBF, BFBF alone, and the control with three replicates. Soil physicochemical properties, microbial abundance, growth parameters, and FTIR-ATR-based bioactive compounds were analysed using one-way ANOVA with Tukey's HSD test. Results showed that the 50% CF + BFBF treatment performed comparably or better than 100% CF in soil N, P, K availability, total soil bacterial abundance, leaf area and methylene (CH₂)_n group associated with the bioactive compound asiaticoside (AS) content. Integrating BFBF into CA cultivation can reduce CF use by nearly half without compromising performance.

Keywords: Biofilm biofertilizer, *Centella asiatica*, Microbial activity, Soil nutrients, Sustainable agriculture

INFLUENCE OF RICE ESTABLISHMENT METHODS ON RICE YIELD AND RICE CROP MANAGEMENT: A QUALITATIVE STUDY AT HAKMANA DS DIVISION, MATARA DISTRICT, SRI LANKA

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Abstract

Rice farmers use different field establishment methods such as broadcasting, transplanting, and the parachute methods. To achieve higher yields, improve resource efficiency, and reduce risks, farmers select rice establishment techniques that best suit their social, economic, and environmental circumstances. This study explored how parachute, transplanting and broadcasting rice establishment methods influence rice yield and crop management practices among farmers in the Hakmana DS Division of the Matara District. Primary data were collected from 10 farmers practicing broadcasting, 10 practicing transplanting, and 10 practicing the parachute method across 10 Grama Niladhari Divisions in the Hakmana DS Division, using purposive sampling and in-depth personal interviews. Data were collected through a semi-structured open-ended interview guide. The data were manually coded, and sub-themes and themes were identified. Farmers' responses indicated that yields were higher in the parachute and transplanting methods. Low yield in the broadcasting method was mainly due to high weed growth and birds attack on the sown seeds. Low cost was associated with the broadcasting method, while high-trained labor requirement was mentioned in the transplanting method. The low seed requirement and needs for trays were mentioned in the parachute method. Farmers perceived the benefits of each method that they used, for broadcasting easy and time-saving method with less labour cost at the expense of seed loss by bird attack, less number of tillers, higher weed growth and pest and disease incidence. In this study, farmers benefited from parachute method with their own labour usage on their small piece of own land.

Keywords: Adaptation, Farmers' responses, Parachute, Qualitative, Rice establishment methods

GRANULAR POLYSULPHATE AS A MULTI-NUTRIENT ALTERNATIVE FERTILIZER FOR COCONUT-GROWING SOILS: A POT EXPERIMENT

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Abstract

Adult coconut palms require large quantities of nutrients, approximately 4.3 kg of inorganic and 30 kg of organic fertilizer per year. Identifying alternative natural nutrient sources is important for sustainable organic coconut cultivation. This study evaluated granular Polysulphate as a natural fertilizer for coconut-growing soils. Polysulphate is derived from naturally occurring polyhalite deposits located beneath the North Sea, United Kingdom, and is processed through mining, crushing, and screening without chemical treatment. A 2-4 mm granular fraction was used in a pot experiment under greenhouse conditions with Madampe soil series, highly suitable for coconut cultivation, to assess the release patterns of K, Ca, Mg and S, as Polysulphate contains 14% K, 48% S, 6% Mg, and 17% Ca. Three treatments were arranged in a Completely Randomized Design with four replicates: T1 (no fertilizer), T2 (Polysulphate) and T3 (Sulphate of Potash (SOP), Source use for organic cultivation + Dolomite). Application rates were calculated based on the soil weight ratio of the manure circle of an adult palm relative to pot soil weight. Accordingly, T2 received 37.77 g Polysulphate, while T3 received 10.35 g SOP and 11.25 g Dolomite. Soil samples collected at two-week intervals were analyzed for available K, Ca, Mg and S using ICP-OES and data were analyzed using one-way ANOVA with Tukey's HSD test ($\alpha=0.05$). T2 showed a significant increase in available K within two weeks (260.30 mgkg⁻¹), peaking at 294.59 mg kg⁻¹ at week four, while T1 and T3 remained low (2-17 mgkg⁻¹). T2 also significantly increased Ca (148.73-212.13), Mg (90.90-117.60) and S (333.59-518.20) mgkg⁻¹, demonstrating its multi-nutrient release capability. These findings suggest that Polysulphate has potential as a multi-nutrient alternative fertilizer, supplying K, Ca, Mg and S for especially organic coconut cultivation, though field studies are needed for confirmation.

Keywords: Alternative, Granular polysulphate, Multi nutrient, Nutrients

SALICYLIC ACID-INDUCED PROLINE ACCUMULATION ENHANCES HEAT STRESS TOLERANCE IN RICE (*Oryza sativa*)

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Abstract

Rice (*Oryza sativa* L.) is the main food crop cultivated in Sri Lanka, and plays a central role in the country's food security. Heat stress demands urgent attention in the context of climate change, as effective physical management options remain limited. Salicylic Acid (SA) is a key phytohormone regulating plant defense and stress responses. This study aimed to evaluate the effect of exogenous application of SA on proline accumulation and heat stress tolerance in rice. Specifically, the study investigated whether SA application at panicle initiation (PI) and flowering (FI) stages enhances proline biosynthesis and mitigates heat stress-induced yield reduction. Samples were taken before application of 0.2 mM SA and five days after application of SA. Control treatment was performed without SA application. The rice variety, Bg 358 is known to be sensitive to heat stress, particularly during reproductive stages, previously been reported to perform poorly under heat stress. Leaf tissues were harvested immediately before the application of SA and five days after application. The same experiment was conducted at one-month intervals to capture the effects of temporal environmental heat variations on rice. The study was conducted in a randomized complete block design with three replicates. Leaf proline was extracted using 3% sulfosalicylic acid and quantified using the acid-ninhydrin colorimetric method. Absorbance at 520 nm was measured using a UV-visible spectrophotometer. A standard calibration curve for L-proline was prepared using serial dilutions of known concentrations. ANOVA was performed with SAS software, and means were separated using Duncan's Multiple Range Test ($p < 0.05$). Plants treated with SA at both PI and FI recorded significantly higher proline content (56.8%) and maintained yields equivalent to those of plants grown without heat stress. The study concluded that the external application of 0.2 mM SA at both PI and FI could enhance plants' responses against heat stress.

Keywords: Colorimetry, Heat stress, Proline, Rice, Salicylic acid

GREEN MANURE INCORPORATION FOR OPTIMUM GROWTH AND YIELD PERFORMANCE OF BRINJAL

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Abstract

Green manure incorporation is an effective strategy for enhancing soil fertility through improved organic matter content, nutrient cycling, and soil physical properties. A field experiment was conducted from March to October 2025 in the Jaffna Peninsula, Sri Lanka, to evaluate the impact of selected leguminous green manure crops on the growth and yield performances of brinjal (*Solanum melongena* L.). The experiment was arranged in a Randomized Complete Block Design (RCBD) with three replicates. The treatments comprised: T₁ – Sunn hemp (*Crotalaria juncea*) incorporation, T₂ – Green gram (*Vigna radiata*) incorporation, T₃ – Black gram (*Vigna mungo*) incorporation, T₄ – Cowpea (*Vigna unguiculata*) incorporation, and T₅ – Control (no green manure and no fertilizers). Green manure crops were incorporated at 50% flowering, followed by an eight-week decomposition period before transplanting brinjal variety Hybrid 704. Growth parameters, including plant height, number of leaves per plant, number of branches per plant, and number of flowers per plant were recorded. Yield attributes such as number of fruits per plant, fruit weight, fruit length, fruit girth, fruit diameter, total fruit yield per plant, and ratoon yield were also evaluated. Data were subjected to statistical analysis using SAS software (9.4). Results showed a consistent superiority trend of T₁ > T₂ > T₃ > T₄ > T₅ across all growth and yield parameters. Sunn hemp incorporation (T₁) recorded the highest plant height (74.93 cm), number of leaves (141), branches (16), and flowers (57), compared to the control (58.17 cm, 84 leaves, 5 branches, and 28 flowers). Sunn hemp incorporation (T₁) recorded the highest number of fruits per plant (37), fruit length (14.77 cm), fruit diameter (3.73 cm), mean fruit weight (90 g), total fruit yield per plant (3300 g), and ratoon yield (1539 g), compared to the control (17 fruits, 11.97 cm fruit length, 3.00 cm fruit diameter, 69 g mean fruit weight, 1150 g total yield per plant, and 535.5 g ratoon yield). These findings demonstrate the significant potential of Sunn hemp as an effective and sustainable green manure for improving soil fertility and enhancing brinjal productivity. Its integration into vegetable-based cropping systems can contribute to environmentally sound and resource-efficient agricultural practices in the Jaffna Peninsula and similar agro-ecological regions.

Keywords: Brinjal, Green manure, Jaffna Peninsula, Soil fertility, Sunn hemp incorporation

DEVELOPMENT OF A COST-EFFECTIVE SPIRULINA CULTIVATION MEDIUM USING RICE BRAN AND AZOLLA EXTRACTS AS NATURAL NITROGEN SOURCES

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Abstract

Commercial cultivation of *Spirulina platensis* relies heavily on synthetic nitrogen sources, such as sodium nitrate in Zarrouk's medium, which increases production costs and limits sustainability. This study aimed to develop a cost-effective and environmentally sustainable alternative cultivation medium by partially substituting sodium nitrate with natural nitrogen sources derived from Azolla and rice bran extracts. Two separate experiments were conducted using Azolla extract and rice bran extract. Each experiment followed a Completely Randomized Design with five treatments: control (100% Modified Zarrouk's Medium) and substitution levels of 10%, 20%, 30%, and 40%. Substitution was based on volumetric replacement of MZM with respective extracts. Each treatment was replicated three times over an 18-day cultivation period. Growth performance was evaluated using dry biomass yield, chlorophyll a content, optical density, and specific growth rate. Data were analyzed using one-way ANOVA at $p < 0.05$. Results showed significant differences among treatments. The control recorded a biomass yield of 14.2 ± 0.30 g/L. The highest biomass (16.0 ± 0.46 g/L) was observed at 20% Azolla substitution, while a higher concentration (40%) resulted in reduced biomass (13.1 ± 0.25 g/L). Chlorophyll a content was highest at 40% Azolla (1.080 ± 0.00015 mg/L). Rice bran extract showed lower performance, with the lowest biomass (2.0 ± 0.04 g/L) at 40% substitution. Overall, Azolla extract demonstrated better potential as a partial nitrogen substitute, supporting sustainable and cost-effective *Spirulina* cultivation.

Keywords: Azolla extract, Nitrogen substitution, Rice bran extract, *Spirulina platensis*, Sustainable cultivation

ANTIFUNGAL ACTIVITY OF KARTHAKOLOMBAN AND VILLARD MANGO EXTRACTS AGAINST *Pestalotiopsis mangiferae* AND *Mucor irregularis* FUNGAL PATHOGENS

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Abstract

In Sri Lanka, mango (*Mangifera indica* L.) farming is highly affected by fungi, including *Pestalotiopsis mangiferae* and *Mucor irregularis*. The by-products generated from this fruit include peel, seed, leaf, and pulp. Nevertheless, the antifungal activity of these by-products has not yet been tested widely. In this research, the antifungal effects of eight ethanol extracts from two varieties of mango grown in Sri Lanka (Karthakolomban (KC) and Villard (VD)) were tested against *P. mangiferae* and *M. irregularis* that were isolated from mango leaves. Extraction was carried out on all four parts of each cultivar. Antifungal properties were tested using the well diffusion method on agar plates, and the minimum inhibitory concentration (MIC) and minimum fungicidal concentration (MFC) were calculated using spectrophotometry techniques. Synergistic interactions between different extracts were investigated using the checkerboard method, and synergism was expressed in terms of the fractional inhibitory concentration index (FICI). The seed extracts provided larger zones of inhibition than any other part of the plants. The seed extract of KC variety showed an MIC value of 6.25 µg/mL for *P. mangiferae* and 50 µg/mL for *M. irregularis*. The seed extract of VD variety provided an MIC value of 12.5 µg/mL for *P. mangiferae* and 6.25 µg/mL for *M. irregularis*. The MFC value was equivalent to that of the MIC value for both pathogens, implying fungicidal effects. The checkerboard test indicated that there was potent synergism between the seed extract of KC variety and VD variety, resulting in FICI values of 0.281 for *P. mangiferae* and 0.070 for *M. irregularis* (FICI ≤ 0.5 is an indicator of synergism). Solvent controls and positive controls were conducted to confirm the experiment. The results show that the extracts from the seeds of the mango have strong antifungal properties, especially those from the KC and VD cultivars, which can work synergistically.

Keywords: Ethanol extracts, Fungicidal activity, Mango by-products, Minimum inhibitory concentration, Plant-based antifungals

**DETERMINATION OF PLANT GROWTH PROMOTING
ACTIVITIES OF BACTERIA ISOLATED FROM *Curcuma longa*
(TURMERIC) RHIZOSPHERE SOIL IN DEHIWALA, WESTERN
PROVINCE, SRI LANKA**

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Abstract

Soil bacteria are prokaryotic microorganisms that inhabit the soil ecosystem and play critical roles in sustaining soil quality and nutrient cycling. Among these bacteria, Plant Growth Promoting Bacteria (PGPB) are essential members. They enhance nitrogen fixation, phosphate solubilization, and ammonia production, and produce phytohormones. They can be used as a sustainable alternative to chemical fertilizers. *Curcuma longa* harbors a diverse community of microorganisms in the rhizosphere that thrive as PGPB. The main purpose of this study is to isolate and characterize plant growth-promoting bacteria from soil samples of *Curcuma longa*. Soil samples were collected from Dehiwala (6.857076/79.864279°). The prepared soil suspension was enriched in nutrient broth and incubated at 27±2°C for 24 hours. For isolation, the enriched culture was serially diluted to 10⁻¹-10⁻⁶. The spread plate and streak plate techniques were used to obtain pure bacterial colonies in nutrient agar. Isolated pure bacterial colonies were screened for plant growth-promoting activities, including phosphate solubilization, ammonia production, nitrogen fixation, and indole-3-acetic acid (IAA) production. Five bacteria were chosen for further characterization. Antagonistic activities among bacterial isolates were screened in selected colonies. Oxidase, catalase, motility and Gram staining were performed for conventional identification. Molecular identification was done using sanger sequencing technique. From pure bacterial cultures, eleven bacterial isolates were obtained (SBD1, SBD2, SBD3, SBD4, SBD5, SBD6, SBD7, SBD8, SBD9, SBD10, SBD11). Nine isolates showed positive phosphate solubilization (SBD1, SBD2, SBD3, SBD4, SBD5, SBD6, SBD7, SBD8, SBD9). All bacteria showed ammonia production and nitrogen fixation activity. Out of eleven bacteria, eight isolates showed IAA production (SBD1, SBD2, SBD3, SBD4, SBD6, SBD8, SBD9, SBD11). Antagonistic activity was negative for all five bacteria (SBD1, SBD4, SBD5, SBD9 and SBD10). All five isolates were oxidase-positive and motile. Catalase activity was detected in three bacterial isolates (SBD4, SBD5 and SBD9). SBD4, SBD5 and SBD9 were Gram-negative and SBD1 and SBD10 were Gram-positive. The selected bacterial isolates were identified as *Kosakonia sacchari* (PZ208711) (SBD5) and *Kosakonia pseudosacchari* (PZ210312) (SBD9). These results indicate that PGPBs have significant potential as eco-friendly

biofertilizers that help develop products providing sustainable, environmentally friendly alternatives to conventional chemical fertilizers.

Keywords: Ammonia production, *Curcuma longa*, Nitrogen fixation, Plant growth-promoting bacteria, Rhizosphere

DETERMINATION OF PLANT GROWTH-PROMOTING ACTIVITIES OF BACTERIA ISOLATED FROM SOIL SAMPLE AROUND *Zea mays* (CORN) PLANT IN BIBILE, SRI LANKA

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Abstract

Plant growth-promoting bacteria that live in association with plants increase their growth and health and protect from pests or diseases by enabling access to nutrients, releasing phytohormones and controlling phytopathogenic agents. *Zea mays* (corn) is the second most important cereal crop in Sri Lanka after rice. Recent studies focus on general plant growth-promoting strains in Sri Lanka, not on location-specific strains capable of surviving real-world environmental conditions. Therefore, determining location-specific bacterial strains capable of enhancing plant growth-promoting activities can help corn agriculture by enhancing yields without harming the environment. Hence, this study aimed to isolate and characterize plant growth-promoting bacteria from *Zea mays* soil samples in Bibile, Sri Lanka. A *Zea mays* soil sample was collected from a natural habitat in Bibile, Sri Lanka. The enrichment process was done then a serial dilution was performed. Pure bacterial colonies were isolated using the spread and streak plate techniques. Screening included phosphate solubilization, ammonia production, nitrogen fixation, IAA production, antagonistic activity, and gram staining, catalase, oxidase, and motility test as conventional identification. The 16S rRNA gene sequencing was used for molecular identification. Spread plate gave clearly separated colonies, and thirteen morphologically distinct isolates were obtained and labeled as SBB1a, SBB1b, SBB2, SBB3, SBB4, SBB5, SBB6, SBB7, SBB8a, SBB8b, SBB9, SBB10 and SBB11. SBB1b, SBB2, SBB4, SBB7, SBB8a and SBB9 were positive for phosphate solubilization (detected by a clear halo on PVK agar). While all the bacteria were positive for ammonia production (detected using Nessler's reagent assay) and nitrogen fixation (measured by growth on Jensen's media), SBB1a, SBB1b, SBB2, SBB4, SBB7, SBB9 and SBB10 were positive for IAA synthesis (detected using Salkowski's reagent with L-Tryptophan). The selected bacterial isolates (SBB2, SBB4, SBB8b, SBB9 and SBB10) did not exhibit antagonistic activity against one another. All five bacteria were Gram-negative and positive for the catalase test. While bacterial isolates SBB2, SBB4, SBB8b and SBB9 were positive for the oxidase test. The bacterial isolates SBB2, SBB8b and SBB10 were identified as motile. SBB8b showed 93% sequence identity to *Bacillus altitudinis* (PZ208707), and SBB9 showed 86% sequence identity to *Pseudomonas mendocina*. Selected isolates indicate potential as biofertilizer candidates, pending greenhouse and field validation.

Keywords: Nitrogen fixation, Plant growth-promoting activities, Plant growth-promoting bacteria, Soil bacteria, *Zea mays*

ISOLATION AND SCREENING OF PLANT GROWTH-PROMOTING RHIZOBACTERIA FROM *Curcuma longa* L. (TURMERIC) RHIZOSPHERE SOIL IN NEGOMBO, SRI LANKA.

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Abstract

The rhizosphere is a biologically active soil region enriched with microorganisms that significantly affect plant growth and soil fertility. Plant Growth-Promoting Bacteria (PGPB) enhance crop productivity by increasing nutrient solubility, synthesizing hormones and fixing nitrogen, providing a sustainable alternative to chemical fertilizers. Turmeric (*Curcuma longa* L.) is an economically and medicinally important crop in Sri Lanka, but there is limited information on the Plant-growth potential of rhizobacteria associated with turmeric soil in Negombo. Therefore, this study aimed to isolate and screen bacteria from the rhizosphere soil of *Curcuma longa* L. for plant-growth-promoting traits. The soil sample was collected from Negombo (7° 12' 53.3236" N, 79° 50' 34.5952" E), and 5 g of the soil sample was used to prepare the soil suspension. Soil suspension (1 mL) was enriched in Nutrient broth for 24 hours at room temperature (27±2 °C), and enriched broth was subjected to serial dilution (10⁻¹ to 10⁻⁶) followed by spread plate and streak plate techniques to obtain pure bacterial isolates. The isolates were qualitatively screened for phosphate solubilization, ammonia production, nitrogen fixation, and Indole-3-Acetic Acid (IAA) production. Five isolates were tested for antagonistic activity and characterized using Gram staining, Catalase, Oxidase, and Motility (Hanging drop) tests. Molecular identification was done using Sanger Sequencing. Fourteen bacterial colonies were isolated from the streak plates. Three isolates exhibited phosphate solubilization (SBN3b, SBN5a, SBN10). All isolates produced ammonia, ten isolates showed growth on nitrogen-free medium, indicating potential nitrogen-fixing ability (SBN1, SBN3a, SBN3b, SBN4, SBN5a, SBN5b, SBN5c, SBN9, SBN10, SBN11) and nine isolates produced IAA (SBN1, SBN4, SBN5b, SBN5c, SBN6, SBN7, SBN8, SBN9, SBN11). None of the isolates showed antagonistic activity against each other. SBN1, SBN5a and SBN10 were Gram-negative, while SBN3b and SBN4 were Gram-positive. Catalase activity was observed in SBN3b, SBN5a and SBN10. All tested isolates were oxidase-positive and motile. SBN3b and SBN5a were found to be *Cytobacillus kochii* and *Serratia marcescens*, respectively, in molecular identification. These findings indicate that *Curcuma longa* L. soil in Negombo contains bacteria with multiple plant-growth-promoting traits. The selected isolates may serve as potential candidates for further evaluation as biofertilizers.

Keywords: 16s rRNA, Biofertilizer, Plant growth-promoting bacteria, Sustainable agriculture, Turmeric rhizosphere

CITRUS ACCUMULATION CHARACTERISTICS OF NHP IN RESPONSE TO CLAs INFECTION

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Abstract

Citrus Huanglongbing (HLB) caused by *Candidatus Liberibacter asiaticus* (CLAs) poses the most devastating threat to global citrus production. Systemic acquired resistance (SAR) is a promising strategy for developing resistant cultivars, and N-hydroxy-pipecolic acid (NHP) is a key SAR signal, yet its role in citrus defense against HLB remains unclear. The dynamic accumulation of NHP and its precursor pipecolic acid (Pip) during CLAs infection, as well as their correlation with citrus HLB tolerance, are poorly understood. In this study, HLB-tolerant Kaffir lime (*Citrus hystrix*) and HLB-susceptible Wanjincheng orange (*Citrus sinensis* Osbeck) were used as materials. CLAs inoculation was performed by branch grafting, NHP and Pip contents were determined by UPLC–MS/MS, and CLAs titer was quantified by qPCR. Results showed that Kaffir lime exhibited stronger HLB tolerance with lower CLAs accumulation than Wanjincheng orange. Both NHP and Pip levels increased after CLAs infection in two cultivars, while NHP content in Kaffir lime was significantly higher than that in Wanjincheng orange at both basal and infected states, especially in stems and roots. It is concluded that basal and induced accumulation of NHP is closely associated with citrus HLB tolerance, indicating that NHP plays a vital role in citrus defense against CLAs infection.

Keywords: Citrus, Huanglongbing, Systemic resistance, NHP, UPLC–MS/MS

VARIED SYMPTOM EXPRESSION AND RESPONSES IN LEAF CHARACTERS OF 21 COMMERCIAL SUGARCANE VARIETIES FOR SUGARCANE WHITE LEAF DISEASE (WLD)

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Abstract

Sugarcane (*Saccharum officinarum* L.) is a perennial grass belonging to the family Poaceae. Sugarcane White Leaf Disease (SCWLD) is a phytoplasma disease that severely damages sugarcane cultivations in Sri Lanka. It is primarily transmitted through infected seed cane and secondarily by an insect vector. The vector of the disease is *Deltocephalus menoni*. Sugarcane White Leaf Disease (WLD) induces a range of physiological and morphological changes in infected sugarcane plants. Those changes vary with the sugarcane varieties. The objective of this research is to evaluate the variation in leaf characters of 21 commercially grown sugarcane varieties affected by WLD in both plant and ratoon crops. The study was conducted at the pathology substation of Sugarcane Research Institute in Siyambalanduwa. The experiment design is split split plot design. Twenty-one varieties under healthy and WLD-infected conditions in both plant and ratoon crops were evaluated with three replications and data were collected at 4th, 8th and 12th weeks after planting and ratooning. Data were analyzed using SAS software version 9.1.3 portable version to test the disease expression of 21 commercial sugarcane varieties. WLD caused strong variations in many key growth parameters leaf length, leaf width and number of leaves. Sugarcane varieties, SL 04 624, SL 88 116, SL 90 6237, SL 92 4918, SL 95 4033 and SLI 121 showed the highest variations while varieties like SL 00 354, SL 83 06, SL 92 4997, SL 95 4430, SL 71 30, SL 86 13, CO 775 and SL 00 603 showed comparatively lower changes in leaf characteristics under WLD infection. Among all varieties, SL 04 624 consistently exhibited the highest level of variation in the measured parameters.

Keywords: Healthy, Infected, Plant, Ratoon, Variety

DEVELOPMENT OF *Trichoderma*-BASED FORMULATIONS FOR THE BIOCONTROL OF *Rigidoporus microporus* (Sw.) OVEREEM CAUSING WHITE ROOT DISEASE IN CINNAMON

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Abstract

White root disease, caused by the necrotrophic fungus *Rigidoporus microporus* (Sw.) Overeem, commonly affects crops such as cinnamon, rubber, and tea. In cinnamon plantations, the disease is more prevalent during dry seasons and is often associated with cultivating in or near former rubber lands. The use of synthetic fungicides for disease management is not compatible with organic cinnamon production. Therefore, this study aimed to develop a *Trichoderma*-based formulation for controlling white root disease in cinnamon plantations in Sri Lanka. Soil samples collected from the Wilpita rainforest and cinnamon-growing areas in the Matara district were used to isolate *Trichoderma* spp. using serial dilution and hyphal tip transfer techniques. Seven isolates were obtained, identified up to the genus level through macroscopic and microscopic characterization and coded for convenience. Acquired pure cultures of *R. microporus* from Cinnamon Research Station were maintained on PDA. Antagonistic activity was evaluated using *in-vitro* dual culture bioassays. Among the isolates, 'TRI 3' exhibited the highest Percentage Inhibition of Radial Growth (PIRG) (52.4%), while 'TRI 4' showed the lowest inhibition (16.0%). Based on PIRG values, 'TRI 3', 'TRI 1', and 'TRI 6' were selected for formulation development. Bio-formulations were prepared using rice bran, maize, and used tea leaves, and their shelf life was evaluated over time. The maize seed-based formulation (MSBF) recorded the highest spore count (6.5×10^7) at 30 days, while all formulations showed a decline in spore concentration by the third month. Although the tea leaf-based formulation (TLBF) exhibited rapid sporulation, it also showed a faster decline in spore viability, whereas MSBF demonstrated relatively greater stability. Nursery evaluation using *R. microporus* inoculated nursery pots, demonstrated that *Trichoderma*-based bioformulations improved seedlings health compared to untreated controls. At 90 days after treatment, TLBF-treated seedlings recorded the lowest mean dead leaf count (0.45 ± 0.77), while the inoculated untreated control showed the highest value (4.67 ± 4.51), indicating that the *Trichoderma*-based formulations contribute to both disease suppression and enhanced seedling growth.

Keywords: Bioformulation, *Cinnamomum verum*, *Rigidoporus microporus*, *Trichoderma* spp., white root disease

EVALUATION OF A PACKAGE OF CULTURAL PRACTICES FOR THE MANAGEMENT OF VERTEBRATE PESTS IN CINNAMON (*Cinnamomum verum* J. Presl) CULTIVATIONS IN SRI LANKA

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Abstract

Cinnamon cultivation is currently gaining considerable attention in Sri Lanka as the country's most prominent foreign-exchange-generating spice crop. Although it is cultivated over a large extent of land, the production of true cinnamon remains insufficient to meet global demand. Among the factors contributing to this yield gap, pest and disease damage plays a major role, with vertebrate pest attacks being particularly significant. To date, no studies have been conducted to identify effective methods for protecting newly emerging cinnamon shoots from vertebrate pests. Therefore, this study aimed to evaluate and compare the effectiveness of selected environmentally friendly cultural practices in reducing vertebrate pest damage on newly emerged cinnamon shoots. Eight treatments were tested: application of a slurry of cow dung (T1), liquid sulfur solution (T2), aqueous extract of crushed neem leaves (T3), extract of rotten vegetables (T4), solution of rotten eggs (T5), and physical barriers using nets (T6) and cut-off cinnamon twigs (T7), compared with a control (T8). Following harvesting, a total of 200 cinnamon bushes with newly emerging shoots were selected and randomly assigned to eight treatments in a Completely Randomized Design (CRD), with 25 bushes per treatment. Analysis of variance indicated significant treatment effects on vertebrate pest damage ($p < 0.05$). After five weeks, the highest damage was recorded in the control treatment (41.26%), whereas T1 (cow dung slurry), T6 (net barrier), and T7 (twig barrier) completely prevented shoot damage (0.00%), representing a 100% reduction relative to the control. According to Tukey's multiple comparison test, these treatments were significantly superior to the control and other higher-damage treatments ($p < 0.05$). In contrast, sulphur solution (T2), neem extract (T3), rotten vegetable extract (T4), and rotten egg extract (T5) resulted in intermediate damage levels of 20.05%, 14.45%, 25.49% and 35.99%, respectively. These findings suggest that selected cultural practices can effectively reduce vertebrate pest damage and contribute to increasing cinnamon production through sustainable management approaches in Sri Lanka.

Key words: Cinnamon shoot damage, Ceylon cinnamon, Sustainable agriculture, Vertebrate pests, Vertebrate pest repellents

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DESIGN AND PILOT EVALUATION OF “SL WILDRICE VERSION 1.0”: AN ANDROID-BASED PARTICIPATORY PLATFORM FOR MAPPING OF WILD RICE IN SRI LANKA

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Abstract

Wild relatives of rice are key germplasm resources for climate-resilient crop improvement, yet their field documentation in Sri Lanka remains constrained by fragmented paper-based workflows. This study was designed, implemented, and pilot-evaluated “SL WildRice”. A multilingual Android application for participatory mapping of under-documented natural habitats by the scientific community towards conservation of wild rice populations. The application was developed using a design and development research framework with the use of Flutter on the client side, using Firebase services for authentication and data cloud management, and using Google Maps-based spatial visualization. Pilot data were gathered from December 2025 to March 2026. Descriptive statistics and exact binomial 95% confidence intervals were calculated. Fisher's exact tests were performed using Python 3.13 (SciPy 1.17.0). Data management was conducted in Microsoft Excel 365. During the pilot period, the application was downloaded by 98 users, of whom 31 submitted geo-tagged observations (31.6% (95% CI: 22.6–41.8) of downloads). Expert review confirmed 22 of the 31 submissions as valid wild-rice records (71.0% (95% CI: 52.0–85.8)), equivalent to 22.4% of all downloads. Among the validated records, 9 (40.9% (95% CI: 20.7–63.6)) represented newly documented locations, whereas 13 (59.1% (95% CI: 36.4–79.3)) were revisits to known sites. All 31 contributors complied with the app submission guidelines, and no statistically significant differences in validation outcome were found, based on gender, age group, education level, or participant type (all $p > 0.05$). These results show that the ‘SL Wild Rice’ mobile application is feasible for operational biodiversity mapping through citizen science and can produce expert-verifiable geospatial records to support conservation and breeding programs.

Keywords: Conservation; Mobile application, Pilot test, SMART agriculture, Wild rice

IDENTIFICATION AND CHARACTERIZATION OF *Fusarium odoratissimum* CAUSING STRAWBERRY LEAF SPOT IN CHINA

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Abstract

Strawberry (*Fragaria*×*Ananassa*) is a commercially important crop in China valued for its fruit quality and economic significance. However, it is highly susceptible to fungal diseases, reducing yield and quality. During a field survey conducted in commercial strawberry fields in Changping District, Beijing, symptomatic ‘Hongyan’ plants exhibiting leaf spot with chlorosis were collected. Tissue isolation from affected leaves yielded *Fusarium* based on the culture characteristics. Preliminary molecular identification using translation elongation factor-1 alpha (*tef1-α*) gene region indicated that the isolate belonged to *Fusarium oxysporum* species complex. Further species-level identification was carried out using multi-locus phylogenetic analyses based on calmodulin (*CaM*), RNA polymerase II largest subunit (*rpb1*), RNA polymerase II second largest subunit (*rpb2*), and beta-tubulin (*tub2*) gene regions. Morphological characters, including colony characteristics, sporodochia, phialides, and conidial morphology, together with molecular data, confirmed the isolate as *Fusarium odoratissimum*. Pathogenicity assays were conducted on detached leaves using mycelial plugs, with sterile PDA plugs as controls, under both wounded and non-wounded conditions, with three replicates per treatment. The results demonstrated that *F. odoratissimum* induced leaf spot with chlorosis, and fulfilled Koch’s postulates. This study identifies *F. odoratissimum* as a leaf spot pathogen in strawberry for the first time worldwide and provides a foundation for future research on its epidemiology and management.

Keywords: First report, Molecular identification, *Nectriaceae*, Pathogenicity, Phylogenetic analysis

AN INTEGRATED IOT-GIS AND NVQ-ALIGNED FRAMEWORK FOR CLIMATE RESILIENCE IN RURAL AGRICULTURE

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Abstract

Smart technologies can help agriculture adapt to climate volatility, but top-down deployment often fails in rural settings due to a lack of local technical capacity. This conceptual paper presents a dual-track framework for enhancing climate resilience in rural agricultural clusters through digital infrastructure and human capital accreditation. Recognising the skills gap as a primary barrier to smart-tech adoption, we outline a roadmap that aligns Climate-Smart Agriculture (CSA) competencies with National Vocational Qualification (NVQ) Levels 3–6. By integrating IoT-GIS networks with a principle of “Repair Autonomy” –local capacity to maintain and repair systems–the framework supports Good Safe Food (GSF) traceability and greenhouse gas (GHG) mitigation (e.g. Alternate Wetting and Drying in paddy). A 5000 MT temperature-controlled hub is defined as a baseline for post-harvest logistical resilience. The framework addresses three systemic gaps: information (lack of real-time soil/moisture data), accreditation (absence of CSA-specific vocational pathways), and logistics (post-harvest inefficiencies). Evidence from analogous contexts in South and Southeast Asia suggests that such integration could improve water use efficiency by up to 27 %, reduce post-harvest losses by 50–70 % and lower external technical support needs by 65 %. We argue that institutionalising technical knowledge within rural basins is critical for bridging global agro-technology opportunities and local adaptation needs. No primary data are presented; the paper offers a strategic, systems-level proposal for climate-vulnerable regions. Future work should pilot the framework in a selected Sri Lankan river basin.

Keywords: Climate resilience, IoT-GIS, NVQ, Post-harvest logistics, Repair autonomy

GEOSPATIAL MAPPING OF SOIL NUTRIENT VARIABILITY FOR SITE-SPECIFIC FERTILIZATION IN WELIGATTA, SRI LANKA

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Abstract

Conventional blanket fertilizer recommendations apply the same nutrient amounts uniformly across varied fields, resulting in considerable resource waste and localized crop failures. This study aimed to evaluate the spatial variability of Nitrogen (N), Phosphorus (P) and Potassium (K) in a 0.69 ha uncultivated field at the UCIARS farm in Hambantota, Sri Lanka, to support site-specific nutrient management (SSNM). A grid-based soil sampling approach was utilized to collect 30 composite samples collected from 15 m×15 m grids at a depth of 15 cm. Laboratory analyses employed the Kjeldahl technique for Nitrogen, Olsen's approach for Phosphorus, and Ammonium Acetate extraction for Potassium. Fertility maps were created in ArcGIS Pro by means of Ordinary Kriging interpolation. The elevation of the study area ranges from 7.328 m to 14 m, and the terrain slopes from south to north affect nutrient movement. The results showed that Nitrogen concentrations were alarmingly low in the southeast to northwest regions, with Nitrogen ranging from 0.066% to 0.218%. Potassium levels were generally sufficient across the field (<105 mg/kg), with certain regions exceeding 300 mg/kg. These results indicate that uniform applications may be ineffective in addressing nutrient deficiencies in northern zones and may lead to excessive Potassium application. Variable Rate Application (VRA) is recommended to target Nitrogen and Phosphorus-deficient zones, thereby optimizing fertilizer use, "problem zones" thus maximizing input expenses, with deficient zones, thereby optimizing fertilizer use, improving crop productivity and supporting environmentally sustainable precision agriculture.

Keywords: GIS, Precision agriculture, Site-specific nutrient management, Soil fertility mapping, Soil nutrient variability

IoT APPLICATIONS IN SRI LANKAN AGRICULTURE: A SYSTEMATIC REVIEW

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Abstract

Rapid climate variability, increasing water scarcity, and rising input costs necessitate a technology-driven transformation in Sri Lankan agriculture. The Internet of Things (IoT) has emerged as a key enabler of smart farming through real-time monitoring, automated control, and data-driven decision-making. Accordingly, this systematic review, conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, aims to (a) categorize major application domains, (b) evaluate technological and performance outcomes, (c) analyze implementation challenges, and (d) identify research gaps and future directions for scalable adoption. This review synthesizes findings from 38 scientific, English-language studies selected from an initial pool of 1567 peer-reviewed articles published between 2018 and 2025. A systematic literature search was conducted in IEEE Xplore, Scopus, and Google Scholar, using Boolean operators (AND, OR) to refine the results. Keywords included ‘Internet of Things’, ‘IoT’, ‘Smart Agriculture’, ‘Precision Farming’, and ‘Sri Lanka’. Following PRISMA-guided identification, screening, and eligibility assessment, relevant studies were included for qualitative thematic synthesis. The selected studies were categorized into five major thematic domains: smart irrigation systems, greenhouse automation, precision nutrient and soil monitoring, AI-based crop monitoring and advisory systems, and blockchain-enabled traceability. Smart irrigation systems (34%) and greenhouse automation (26%) emerged as the dominant research areas. Smart irrigation technologies demonstrated notable improvements in water-use efficiency, while greenhouse automation systems reported increased yield under controlled conditions. Precision nutrient and soil monitoring enhanced fertilizer-use efficiency, whereas AI-based crop monitoring systems improved early disease detection and crop health assessment. Blockchain-based applications, primarily used for supply chain traceability, transparency, and food safety assurance, remain at an early pilot stage, with limited real-world deployment in Sri Lanka. Despite demonstrated technical feasibility, large-scale adoption is constrained by inadequate rural infrastructure, high initial investment costs, interoperability challenges, and limited digital literacy among farmers. In conclusion, IoT-enabled smart farming systems show strong potential to enhance productivity, sustainability, and climate resilience in Sri Lanka, provided that enabling policies, infrastructure development and capacity-building initiatives are strengthened.

Keywords: Climate-smart agriculture, Greenhouse automation, IoT agriculture, Smart irrigation, Sri Lanka

TOWARDS INTEGRATED CLIMATE-SMART AGRICULTURE IN SRI LANKA: CSA PROJECT PORTFOLIO COHERENCE AND GAPS (2020–2025)

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Abstract

Sri Lanka's agriculture sector contributes approximately 8 per cent of GDP and employs over 26 per cent of the national labor force. The sector faces compounding pressures from recurring climate shocks and the 2022–2023 economic crisis. Numerous Climate-Smart Agriculture (CSA) projects have been implemented through multiple government agencies in collaboration with multilateral funders, yet their collective performance against the three FAO-defined CSA pillars remains unassessed. This study addresses that gap through NVivo 15-assisted qualitative document analysis of eleven CSA projects implemented from 2020 to 2025. Thirty-nine project documents were coded using a deductive framework of thirty sub-codes across five thematic nodes and six implementation challenge categories. Results reveal that climate adaptation dominates the portfolio with 223 coding references. Productivity is moderately covered at 131 references but concentrated in two projects. Mitigation is critically absent with only 32 incidental proxy references across five projects. Two portfolio-wide structural failures are identified: institutional coordination deficit documented across eight or more projects, and financial sustainability gaps recurring regardless of funding source. The study concludes that structural fragmentation characterizes Sri Lanka's CSA investment landscape and that no project currently contributes measurable greenhouse gas reductions toward the country's Nationally Determined Contribution commitments. Three recommendations are proposed: establishing a National CSA Coordination Platform; mandating mitigation integration in all future CSA projects; and requiring financial sustainability plans as mandatory primary project outputs.

Keywords: Climate-smart agriculture, CSA pillars, Institutional coordination, NVivo 15, Portfolio assessment, Sri Lanka

VALIDATION OF THE iFARM SYSTEM IN CORN PRODUCTION VULNERABLE AREAS IN SOCCSKSARGEN, PHILIPPINES

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Abstract

This study assessed the performance and operational efficiency of the Integrated Farm Attribution for Risk and Resource Monitoring and Management (iFARM) system as a digital platform for near real-time monitoring of corn production, crop damage, and intervention tracking in support of Disaster Risk Reduction and Management (DRRM) in climate-vulnerable areas of SOCCSKSARGEN, Philippines. A descriptive, field-based research design employing total enumeration of farmers registered under the Registry System for Basic Sectors in Agriculture (RSBSA) was used. Data were collected using standardized digital forms embedded in the iFARM system, integrating farmer profiling, georeferencing, and crop monitoring protocols. Descriptive statistics, frequency distribution, and correlation analyses were performed using IBM SPSS Statistics. A total of 816 registered farmers with a declared area of 1267.62 ha were assessed; however, validation confirmed only 134 active corn farmers cultivating 188.42 ha, revealing substantial discrepancies (86.6% reduction in farmer count and 85.1% reduction in the area) between registry and actual population data. The system effectively captured key agronomic variables, showing predominance of hybrid (45%) and genetically modified (28%) yellow corn, with 53% of farmers relying on government provided seeds. Mean grain yield reached 3.95 t ha⁻¹, with total production of 299.6 metric tons. Drought incidence was low (1.35%), but significant pest pressures were recorded, including fall armyworm (*Spodoptera frugiperda*), corn borer (*Ostrinia furnacalis*) and corn planthopper (*Peregrinus maidis*). Common diseases recorded were maize streak virus (MSV), downy mildew (*Peronosclerospora philippinensis*), leaf blight (*Exserohilum turcicum*) and stalk rot (*Fusarium* spp.). Implementation of a multi-level validation protocol improved data accuracy, minimized duplication, and enabled reporting within 1-5 days. The iFARM integration framework significantly enhanced data validation, minimized reporting errors, and enabled evidence-based decision-making, demonstrating strong potential for improving agricultural monitoring, climate risk management and policy development.

Keywords: Corn production monitoring, Damage assessment, Digital agriculture, iFARM system, Pest and disease surveillance

EVALUATING THE POTENTIAL OF PET BOTTLE RECYCLING FOR SUSTAINABLE TEXTILE PRODUCTION IN SRI LANKA

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Abstract

This study evaluated the potential of Polyethylene Terephthalate (PET) bottle recycling for sustainable textile production in Sri Lanka, focusing on recycling practices, feasibility of integration into the textile sector, and related environmental and economic impacts. The textile and apparel industry is one of Sri Lanka's major export sectors, emphasizing the importance of sustainable production approaches. With increasing plastic waste and demand for eco-friendly materials, recycled PET (rPET) offers a promising solution within the circular economy. A mixed-method research design was used, combining secondary data analysis with two primary surveys and a SWOT analysis. Secondary data were collected from government reports, industry publications, and international databases. The first survey assessed the Knowledge, Attitudes, and Practices (KAP) of the general public regarding PET recycling. A sample of 300 respondents from different parts of Sri Lanka was selected using convenience sampling through online distribution. Data were analyzed using IBM SPSS Statistics version 25 and due to non-normality, Mann-Whitney U and Kruskal-Wallis tests were applied. The second survey targeted 78 stakeholders from the Sri Lankan textile and recycling sectors, including manufacturers, recyclers, government agencies and research institutions. Participants were selected using purposive and snowball sampling methods. Descriptive statistics and cross-tabulations were used for analysis, while semi-structured interviews supported the SWOT analysis. Results showed that Sri Lanka's PET recycling system remains underdeveloped, with only about 11% of plastic waste recycled. Although public attitudes toward recycling were positive (mean=14.99), knowledge (mean=1.54) and practices (mean=7.88) remained inconsistent. Education level and occupation significantly influenced knowledge levels ($p<0.05$). Nearly half of the industry stakeholders had already adopted or explored rPET integration, indicating moderate industry readiness. However, technical barriers such as plastic degradation (26.9%) and contamination (16.7%) were major challenges. Stakeholders identified certification standards and government incentives as key drivers for adoption. The study concludes that Sri Lanka has strong potential for sustainable textile production through rPET, but improvements in infrastructure, policy support, technology and public awareness are necessary for long-term implementation.

Keywords: Circular economy, PET recycling, recycled PET (rPET) textiles, Sri Lanka, Sustainability

**ADVANCEMENTS IN FOOD PROCESSING
AND POSTHARVEST TECHNOLOGIES**

BIOPRESERVATION USING MICROBIAL CONSORTIA IN POSTHARVEST SYSTEMS: A COMPREHENSIVE REVIEW OF ECOLOGICAL INTERACTIONS, MECHANISTIC INSIGHTS, AND CHEMICAL-FREE PRESERVATION STRATEGIES

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Abstract

Postharvest losses in fruits and vegetables remain a major challenge to food security, economic stability, and environmental sustainability, with losses in Sri Lanka estimated at 20–40% due to inadequate handling, storage, and microbial spoilage. Conventional preservation methods relying on synthetic chemicals and fungicides raise concerns related to human health, environmental toxicity, and microbial resistance. Therefore, safer and sustainable alternatives are increasingly needed. Microbial consortia, defined as interactive communities of microorganisms, have emerged as promising bio-preservative agents with greater stability, adaptability and multifunctionality than single-strain systems. Globally, studies report that microbial consortia can reduce postharvest decay by up to 50–80% under controlled conditions, highlighting their effectiveness in real-world applications. This review aimed to (1) examine ecological interactions shaping microbial consortia, (2) explore underlying preservation mechanisms and (3) evaluate their practical applications and limitations. A literature review (2010–2024) using PubMed, Scopus, Web of Science, and Google Scholar was conducted. Microbial consortia function through mutualism, syntrophy, and competitive exclusion, enhancing colonization and suppressing spoilage organisms. Mechanisms include production of antimicrobial compounds, quorum sensing regulation, enzymatic degradation, and host–microbe interactions, supporting biofilm formation and stress tolerance. Advances in omics, synthetic biology, and machine learning enable targeted consortium design. However, challenges such as regulatory barriers and scalability persist. Future applications in Sri Lankan fruits and vegetables should focus on developing cost-effective, locally adapted consortia integrated into existing supply chains, enabling reduced postharvest losses, lower chemical inputs, and improved economic returns through minimized waste and enhanced market value.

Keywords: Bio preservation, Ecological interactions, Microbial consortia, Postharvest spoilage, Sustainable food systems

EVALUATION OF PHYSICOCHEMICAL PROPERTIES AND SENSORY ATTRIBUTES OF FRUIT LEATHERS DEVELOPED FROM BANANA AND PAPAYA

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Abstract

Fruits are perishable and undergo undesirable changes if untreated, necessitating processing into shelf-stable, value-added products to reduce post-harvest losses. Fruit leathers, prepared from fruit puree, are nutritious snacks. In Sri Lanka, substantial postharvest losses of banana and papaya highlight the need for preservation through fruit-based products. This study aimed to develop banana- and papaya-based fruit leathers at different ripening stages and identify the best formulation based on physicochemical and sensory attributes. Fresh sour plantain (*Musa acuminata*) and papaya (*Carica papaya*) at three ripening stages (ripe, very ripe, and overripe) were pureed, mixed with 0.8% lime juice, 2% honey, and 12.5% drinking water (w/w), and dehydrated at 60 °C for 8 h 30 min to 12–20% (wet basis) moisture using a hot-air dryer. Fruit leathers with banana-to-papaya ratios of 1:1, 1:2, 2:1, 1:3, and 3:1 were also prepared using overripe fruits. Raw fruits were analyzed for pH, total soluble solids (TSS), titratable acidity (TA), firmness, and color (L*, a*, b*). Banana, papaya, and selected mixed fruit leathers (1:1, 1:2, and 1:3) were analyzed for moisture content, water activity, pH, TSS, TA, vitamin C, total phenolic content, carotenoids, and color. Sensory evaluation was also conducted. Results showed that ripening stage significantly affected physicochemical properties. In banana leather, moisture content decreased from 28.96% to 18.55% with a reduction in water activity. Similarly, papaya leather showed decreases in moisture (30.39–11.84%) and water activity (0.55–0.48), while TSS increased from 74.80 to 88.73 °Brix, indicating improved drying efficiency and shelf stability. Overripe banana leathers recorded higher TSS (68.2%) and TA (1.58%), whereas overripe papaya leathers showed greater brightness (L* = 20.25) and phenolic content (3.66 mg GAEg⁻¹). Among mixed formulations, the 1:3 banana-to-papaya ratio exhibited the highest nutritional quality, with maximum vitamin C (116.6 mgkg⁻¹), total phenolics (3.93 mg GAEg⁻¹), β-carotene (28.2 mgkg⁻¹), and lycopene (5.7 mgkg⁻¹) contents. This formulation also received the highest sensory acceptability. The study demonstrates that combining overripe banana and papaya at a 1:3 ratio improves the nutritional and sensory quality of fruit leather while promoting fruit waste reduction and value addition.

Keywords: Banana, Fruit leather, Papaya, Physicochemical properties, Postharvest losses

CHARACTERIZATION OF FLOUR AND STARCH FROM *Nymphaea pubescens* (HAIRY WATER LILY) SEEDS AND THEIR APPLICATION IN WHEAT-BASED PASTA FORMULATIONS

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Abstract

Nymphaea pubescens seeds are an underutilized carbohydrate-rich resource. This study aimed to characterize flour and starch extracted from *N. pubescens* seeds in terms of morphological, physicochemical, and structural properties and to evaluate their suitability in pasta formulations. Starch was prepared by soaking in 0.25% NaOH solution overnight at 4 °C, followed by wet milling, centrifugation and vacuum drying at 45°C for 2 h. Light microscopy showed heterogeneous flour particles and oval-to-round starch granules with smooth surfaces. FTIR confirmed crystalline and amorphous starch regions (994 cm⁻¹ and 1152 cm⁻¹) and effective protein removal (reduced 1637 cm⁻¹ band). Starch contained an amylose content of 18.16±0.68% (w/w) as determined by the iodine colorimetric method after dispersion in Dimethyl Sulfoxide (DMSO). Flour exhibited a water holding capacity of 0.79±0.06 g g⁻¹, oil holding capacity of 1.12±0.15 gg⁻¹, solubility of 2.83±0.76%, and swelling power of 3.28±0.14 gg⁻¹. Starch displayed water holding capacity of 0.99 ±0.01 g g⁻¹, oil-holding capacity of 1.05±0.03 g g⁻¹, solubility of 2.40±0.07%, and swelling power of 2.27±0.05 g g⁻¹. Pasta was produced by substituting wheat flour with *N. pubescens* seed flour at 15%, 30%, and 45% levels, with 100% (w/w) wheat flour pasta as the control. Formulations were evaluated for cooking quality (optimum cooking time, water absorption, gruel solid loss) and sensory attributes (appearance, aroma, taste, texture, acceptability). Incorporating up to 30% *N. pubescens* flour in pasta formulations significantly increased the optimum cooking time, without affecting water absorption. Sensory evaluation confirmed that pasta with this level of flour is acceptable to consumers. This study demonstrated that *N. pubescens* flour can be incorporated into wheat-based pasta formulations at levels up to 30% without compromising cooking quality, highlighting its potential as a novel alternative food ingredient.

Keywords: *Nymphaea pubescens*, Physicochemical properties, Starch characterization, Wheat substitution

PROTEIN DEFICIENCY AMONG ADOLESCENTS IN JAFFNA DISTRICT: ASSOCIATION WITH HABITUAL DIETARY CONSUMPTION PATTERN

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Abstract

Adolescent nutrition is crucial for supporting rapid physical growth, hormonal changes and cognitive development. Adequate dietary protein intake is essential for optimal growth and development during adolescence. However, food consumption patterns in low- and middle-income settings are often dominated by staple foods with limited intake of protein-rich sources. Evidence linking habitual food consumption patterns with biochemical indicators of protein status among Sri Lankan adolescents is limited. This cross-sectional descriptive study was aimed to assess the association between food consumption patterns and biochemical protein deficiency among 752 adolescents (17-19 years) in Jaffna District, Sri Lanka. The ethical approval was obtained from the Ethics Review Committee, Faculty of Medicine, University of Jaffna. A multistage sampling technique was used to select the study sample by household visits in 35 Grama Niladhari divisions of Jaffna district. Socio-demographic information was collected using an interviewer-administered questionnaire while dietary intake was assessed using a food frequency questionnaire and a food diary. Venous blood samples were obtained to determine serum albumin levels using the Bromocresol Green method, and protein deficiency was defined as serum albumin ≤ 3.8 g/dL. The prevalence of biochemical protein deficiency among the participants was 16.3% (n=123). The Chi-square test was applied to examine the relationship between food consumption and protein deficiency at a significance level of $p < 0.05$. The results showed significant associations between protein deficiency and the consumption of selected staple and protein-rich foods. A higher prevalence of protein deficiency was observed among adolescents with frequent consumption of white rice-based meals (0.03) and wheat pittu (0.01). Consumption of animal-source foods fish (0.01), chicken (0.01) and beef (0.03) demonstrated an association against protein deficiency ($p < 0.05$). There were no significant relationships found between protein deficiency and the intake of parboiled rice, red rice, dhal, fruits, milk and dairy products ($p > 0.05$). The results provide evidence for planning nutrition interventions that focus on promoting affordable locally available plant and animal base protein foods in school and household diets. It will improve adolescent protein status and strengthen food and nutrition security in Northern Sri Lanka.

Keywords: Adolescents, Jaffna, Food consumption, Protein deficiency, Serum albumin

ASSESSMENT OF *Listeria monocytogenes* CONTAMINATION IN RETAIL MILK: A STUDY FROM GAMPAHA DISTRICT, SRI LANKA

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Abstract

Listeria monocytogenes is a highly virulent foodborne pathogen responsible for human listeriosis. It can thrive at refrigeration temperatures and may be present in milk and other dairy products due to contamination. Its psychrotrophic nature facilitates growth in chilled milk, posing a substantial public health concern. Raw milk can be contaminated with *L. monocytogenes* due to poor hygiene, infected animals, or environmental exposure. Although pasteurization effectively destroys vegetative pathogens, contamination may persist due to inadequate treatment or post-processing recontamination. Hygiene practices among different manufacturers of pasteurized milk products may vary, and raw milk supplied by informal vendors is also commonly available in retail markets. This necessitates continuous microbiological surveillance to ensure milk safety. Therefore, this study aimed to evaluate the presence of *L. monocytogenes* in raw and pasteurized milk samples randomly purchased from retail markets across the Gampaha District, Sri Lanka. A total of 28 milk samples were analysed, including 16 pasteurized milk samples and 12 raw milk samples. These samples were subjected to selective enrichment for *L. monocytogenes*. After enrichment, a loopful of broth was streaked onto Listeria Selective Agar (LSA) for the selective isolation. After incubation at 37 °C for 24–48 hours, small black colonies surrounded by a distinct blackening of the medium were selected as suspected *L. monocytogenes* isolates and subcultured onto nutrient agar to obtain pure cultures. All isolates were confirmed as Gram-positive, rod-shaped bacteria. Standard biochemical tests were performed for definitive identification, using *L. monocytogenes* (ATCC 19111) as a reference strain. *L. monocytogenes* was detected in 32% of the pasteurized milk samples and 25% of the raw milk samples analysed. The high prevalence in pasteurized milk specifically suggests post-processing contamination. These findings underscore the urgent need for improved hygienic practices in milk handling and highlight the importance of sustained surveillance to mitigate public health risks associated with milk consumption.

Keywords: *Listeria monocytogenes*, Listeriosis, Milk safety, Public health risk, Dairy products

ANALYSIS OF MILLING CHARACTERISTICS OF RAW AND PARBOILED RICE IN DIFFERENT VARIETIES UNDER DIFFERENT METHOD OF MILLING

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Abstract

Insufficient scientific data exists in Sri Lanka regarding how processing methods and machinery impact rice milling recovery and grain quality. This study quantifies performance and quality loss differences when raw and parboiled rice varieties are processed via high-precision research equipment versus farmer-level machinery. A 2×7×2 multivariate factorial experimental design was conducted with all seven rice varieties two processing types (raw and parboiled) and two milling conditions (research grade and farmer level). Research-grade milling utilized a Satake THU-35B De-husker and TM05C Polisher, while farmer-level milling utilized a DOMA CTP20 Automatic mill. Milling characteristics and Thousand-grain weight (TGW) were measured using Precisa BJ210C Electric balance and Precisa XT220 analytical balance. Data were analyzed using semi-parametric MANOVA with Wald-type and ANOVA-type statistics via Wild Bootstrap resampling. Factorial ANOVA was performed on (TGW). The analysis revealed that all main effects and all interaction terms were remarkably statistically significant ($p < 0.001$). Milling outcome depend on the synergy of milling machine, rice type, and rice variety. Results showed that research-grade conditions significantly outperformed farmer-level machinery, achieving higher Head Rice Yield (HRY) and total milled rice yield. Farmer-level machinery exhibited substantial inefficiencies, most notably high hull residue, which indicates poor sheller performance. Parboiled rice demonstrated superior milling behavior across both systems; the synergy between parboiling and research-grade processing yielded the highest HRY. Rice variety had the greatest impact on TGW. These results provide empirical validation for parboiling as an effective method for quality stabilization and underscore the economic necessity of adopting calibrated, precision milling strategies at commercial scales.

Keywords: Head Rice Yield (HRY), Machinery performance, Parboiling, Rice, Thousand-grain weight (TGW)

COMPARATIVE ASSESSMENT OF NUTRIENT COMPOSITION AND ADULTERATION IN RAW COW'S MILK FROM SMALLHOLDER FARMS AND COLLECTION CENTERS IN LANKAPURA, SRI LANKA

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Abstract

Maintaining uniform milk quality is essential for strengthening rural dairy economies and improving supply chain effectiveness. This study evaluated the physicochemical quality of unprocessed cow's milk in Lankapura, Polonnaruwa district, in Sri Lanka by comparing samples collected from small-scale households (n=25) and bulk milk collecting centers (n=25). The objective of the study was to evaluate nutrient composition, detect potential adulteration, and examine quality limitations affecting value realization in the local dairy supply chain. Specific gravity (SG), fat, protein, lactose, and Solids-Not-Fat (SNF) of the milk samples were analyzed. According to the statistical analysis, no significant difference was observed between household and bulk milk samples, suggesting that adulteration or quality deterioration during collection and transportation is minimal. Household milk showed more fat (4.36%) and protein (2.79%) than bulk milk (4.12% fat and 2.74% protein), whereas bulk milk had a marginally higher SNF (7.65% vs. 7.57%), perhaps due to pooling of milk from multiple sources. Although fat content exceeded the national minimum standard (3.5%), both SNF ($\geq 8.5\%$) and protein ($\geq 3.2\%$) remained consistently below recommended levels. The average specific gravity of household milk samples was 1.028, while bulk milk samples showed a slightly higher value of 1.029, both of which fall within the European Union standard range for raw whole milk (1.027–1.035). These results indicate that compositional deficiencies are mainly caused by farm-level nutritional and management gaps, highlighting the need for improved feeding, farmer advisory services, and technology support to enhance dairy productivity and farmer income.

Keywords: Dairy supply chain, Milk quality, Nutritional management, Untreated cow's milk

QUALITY CHARACTERISTIC EVALUATION OF JACKFRUIT (*Artocarpus heterophyllus*) BULB FLOUR PREPARATION BY USING DIFFERENT TREATMENTS, DRYING METHODS AND STORAGE METHODS

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Abstract

This study optimized Jackfruit Bulb flour (JFB) production from underutilized *Artocarpus heterophyllus* bulbs to reduce Sri Lanka's reliance on imported wheat flour. Bulbs underwent anti-browning treatments (blanching, natural and synthetic ascorbic acid, 0.05% w/v Sodium Metabisulfite/SMS), size reduction, drying (tray and oven drying), grinding, and sieving (200 μm) before evaluating physicochemical, functional, and antioxidant properties over 4 weeks at room temperature and refrigerated storage. The SMS 0.05% treated tray-dried flour was selected via colorimetry for the highest lightness ($L^*=97.14\pm 1.18$). The room temperature stored sample exhibited water absorption capacity (WAC) of 2.04 ± 0.25 to 1.34 ± 0.06 g g^{-1} , oil absorption capacity (OAC) of 1.29 ± 0.06 to 0.48 ± 0.03 gg^{-1} over 4 weeks. The refrigerated condition, WAC 1.94 ± 0.05 to 1.58 ± 0.04 gg^{-1} , OAC 1.1 ± 0.01 to 1.05 ± 0.02 g g^{-1} over the 4 weeks. Also, it exhibited swelling capacity of 3.47 ± 0.06 mL g^{-1} , pH 6.05 to 6.12, sinkability of 2.64 ± 0.09 s, titratable acidity of $0.93\pm 0.05\%$ (elevated due to SMS) and water activity of 0.67 ± 0.05 . Antioxidant activity included DPPH IC_{50} of 826 ppm and total phenolics of 23.52 ± 0.93 mg GAE g^{-1} . According to the findings, refrigerated storage best preserves WAC and OAC properties, extending shelf life. Future study focuses on improving their shelf life during storage and preparing the product by using JFB composite flour for product development.

Keywords: Functional properties, Jackfruit bulb flour, Physiochemical properties

INVESTIGATION OF IMPACT OF POST HARVEST STORAGE TIME ON PHYSICAL, MILLING AND COOKING PROPERTIES OF RICE

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Abstract

Despite the importance of proper post-harvest handling, there is limited data correlating storage time with key rice quality parameters. Consequently, farmers and processors lack the evidence-based guidelines to determine the optimal storage period before milling for superior rice quality. This study investigated how post-harvest storage duration influences the physical qualities, milling performance, and cooking properties of rice under typical local storage conditions. Addressing the practical issue of quality deterioration during storage, 12 variety of paddy samples were evaluated at 2, 3, 4, 5, and 6 months. Standard laboratory methods were used to assess physical traits such as grain shape/size, thousand-grain weight, L/W ratio, moisture content and chalkiness, milling quality (BR%, HULL%, TMR%, HG%, BrG%), cooking characteristics including water absorption, volume expansion, elongation ratio and gelatinization temperature. Data were analyzed in R Studio using MANOVA, with chi-square and Fisher's exact tests applied where relevant at a 5% significance level. Storage time produced statistically significant effects on several quality traits. Moisture content consistently decreased with ageing, and minor improvements in grain appearance such as reduced chalkiness in some varieties were recorded. Milling quality, however, improved with longer storage, evidenced by increased head rice yield and less broken grains. Most varieties such as At 311, Bg 352, Bg 360, Bg 94-1, At 378, Bw 367 and Bw 372, a five month storage period showed the highest HG% and Bg 366, Bg 300 showed lowest HG% in longer storage. Cooking properties showed only slight variation across storage periods. Multivariate analysis confirmed a significant combined influence of storage duration on the assessed quality parameters. Overall, the findings show that quality changes in paddy are time-dependent and become more evident with prolonged storage, providing useful guidance for millers and post-harvest managers to optimize storage practices and minimize quality losses.

Keywords: Cooking, Milling, Physical, Quality, Storage

POTENTIAL POSTHARVEST TECHNOLOGIES FOR EXTENDING THE SHELF LIFE OF MICROGREENS IN SRI LANKA - REVIEW

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Abstract

Microgreen cultivation can be considered an emerging and gradually developing sector in Sri Lanka. They are edible, tender leafy greens produced from vegetable and herb seeds. Importantly, microgreens have gained popularity as a “superfood” due to their high nutritional quality and potential health benefits. Microgreens can be cultivated at the household level and in hydroponic and vertical farming systems in Sri Lanka. The main microgreen types produced in Sri Lanka include radish, mustard, cabbage, beetroot, red amaranth, pea shoots, and others, with the primary market consisting of supermarkets and hotels. However, the main bottleneck in the microgreen industry is their short shelf life and rapid quality deterioration, which limit commercial value. This review examines the current status of microgreen production in Sri Lanka, popular microgreen types and their production systems, the main pioneers involved in microgreen cultivation, the reasons for adopting postharvest technologies, and possible postharvest technologies such as cold storage, sanitation treatments, modified atmosphere packaging (MAP), and light-based technologies. Moreover, the challenges and prospects of postharvest technologies are also addressed. The literature reviewed in this study was collected from databases including Scopus, Web of Science, Google Scholar, and ScienceDirect, covering the period from 2010 to 2025. Additional information was also collected from relevant websites related to microgreen producers. Among the reviewed sources, cold storage systems, proper packaging methods, and coating applications appear to be the most suitable postharvest technologies for preserving the quality of microgreens in Sri Lanka. Many technologies are not widely adopted in Sri Lanka due to technological, financial, and practical constraints. Since limited research has been conducted at the Sri Lankan level, there is a need to promote cost-effective and eco-friendly postharvest technologies. Future efforts should focus on developing and promoting postharvest technologies among farmers, securing government support, developing policy, and carrying out extension services for consumers.

Keywords: Cold storage, Microgreens, Modified atmosphere packaging, Shelf life, Vertical farming

DEVELOPMENT OF INCENSE STICKS USING SUGARCANE BAGASSE AND LEMONGRASS FOR MOSQUITO REPELLENCY

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Abstract

An experiment was carried out at the entomology and processing technology laboratories and the research farm of the Sugarcane Research Institute, Uda Walawe, Sri Lanka to create and assess herbal mosquito repellent incense sticks developed from sugarcane bagasse and lemongrass (*Cymbopogon citratus*). This research provided a viable, low cost, environmentally safe alternative to synthetic mosquito repellents with underused agricultural by products. Sugarcane bagasse and lemongrass (*C. citratus*) leaves were collected, processed and developed into incense sticks made with different concentrations. Six different formulations (T1-T6) were prepared and subjected to comprehensive analysis. The methodology included evaluating physical properties such as moisture content (T1–6.42%), (T1–7.70%), burning duration, ash content (T1–2.16%, T1–2.10%), conducting microbial safety analysis (yeast and mold count), and performing sensory evaluations. The primary effectiveness was determined through in vivo laboratory and field test against *Aedes aegypti* mosquitos focusing on knockdown and repellency rates. The results confirmed the viability of the developed product with Treatment 3 (T3) emerging as the most effective formulation. Treatment 3 Demonstrated superior insecticidal properties, achieving the highest mean number of paralyzed mosquitoes ($P = 10.52 \pm 0.50$), and strong repellent action, recording the lowest mean mosquito presence ($P = 0.19 \pm 0.08$) in the initial repellency stage. Furthermore, the developed incense sticks met acceptable standards for microbial quality (5.0×10^{-5} CFU g/ml) and sensory preference.

Keywords: *Aedes aegypti*, Incense sticks, Mosquito repellency, Lemongrass powder, Sugarcane bagasse

DETERMINING OPTIMAL MATURITY INDICES OF ‘RED LADY’ PAPAYA (*Carica papaya L.*) FOR TUTTI FRUTTI PROCESSING

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Abstract

Papaya (*Carica papaya L.*) production in Sri Lanka suffers post-harvest losses of 20–40% primarily due to improper harvest timing, undermining the economic potential of value-added products such as tutti frutti. This study identified the optimal maturity stage of ‘Red Lady’ papaya for high-quality tutti frutti production and established practical farmer-applicable harvest indicators. Fruits were harvested at six maturity stages (S1–S6; 7–12 weeks post-fruit set) from a commercial plantation in Pubuduwewa, Wellawaya, Sri Lanka, using a simple random sampling with three replicates per stage. Physical (weight, firmness, Munsell peel and flesh color), chemical (°Brix, pH, titratable acidity), and sensory attributes (37 panelists; 9-point hedonic scale) were assessed; tutti frutti was prepared by osmotic dehydration to 65 °Brix and drying at 55 °C. Microbiological quality and water activity were determined for the optimal stage. Data were analyzed using one-way ANOVA, Tukey’s HSD, Kruskal-Wallis, and Pearson’s correlation (IBM SPSS v26.0). Stage 4 (10 weeks post-fruit set) was identified as optimal, achieving the highest mean overall acceptability of 37.78 ± 1.95 ($F = 30.15$, $df = 5, 216$, $p < 0.001$), with peak scores for color (7.67), texture (7.30), and flavor (7.67). The chemical profile (7.37 °Brix, pH 6.28, acidity 0.00138%) and firmness (1.07 mm) were ideal for candied fruit processing. The light greenish-grey peel (Munsell 10GY 7/1) provides a reliable, low-cost visual harvest indicator. Microbiological testing confirmed safety (Salmonella absent in 250 g; molds $\leq 1 \times 10^2$ CFU g⁻¹; aerobic plate count $\leq 1 \times 10^4$ CFU g⁻¹) and shelf stability (water activity 0.48 ± 0.02). Harvesting ‘Red Lady’ papaya at 10 weeks post-fruit set, identifiable by its light greenish-grey peel coloration, is recommended to optimize tutti frutti quality and reduce post-harvest losses in Sri Lanka’s papaya industry.

Keywords: Candied fruit, Maturity indices, Post-harvest losses, Red Lady papaya, Sensory evaluation

STRUCTURAL CHANGES IN FOODS DURING DRYING: IMPLICATIONS FOR REHYDRATION CHARACTERISTICS

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Abstract

Drying is a widely used food preservation method; however, it induces significant micro-structural alterations in biological materials that influence their subsequent water absorption capacity during re-hydration. This study investigated the effects of cellular structural changes during hot-air drying on the de-sorption–adsorption behavior of food materials using pumpkin (*Cucurbita maxima* cv. Teggiano) and potato (*Solanum tuberosum* cv. Sebago) as model systems. Pumpkin samples were dried at 55, 60, 65, and 70°C under a constant air velocity of 1.6 ms⁻¹ until moisture content decreased below 5% (wet basis). The dried samples were subsequently re-hydrated in distilled water at 25°C for 5 h until equilibrium moisture content was reached. Potato samples in fresh, dried, and re-hydrated states were examined using Scanning Electron Microscopy (SEM) to qualitatively evaluate cellular structural transformations. The de-hydration–re-hydration kinetics revealed an irreversible trend, as none of the samples regained their initial moisture content after re-hydration. Furthermore, moisture recovery progressively declined with increasing drying temperature, indicating greater structural collapse at higher thermal conditions. SEM observations supported these findings by showing intact cellular geometry in fresh tissues, deformed and open cellular structures in dried samples, and compact closed-cell structures in re-hydrated tissues that restricted further water uptake. The combined kinetic and microscopic evidence suggests that shrinkage and collapse of cellular volume during de-hydration reduce the effective water-holding capacity and limit re-hydration efficiency. However, this behavior may differ in materials that develop porous structures during de-hydration, as such structures can enhance water absorption through capillary action. These findings highlight that re-hydration cannot fully reverse drying-induced micro-structural damage and that drying temperature is a key factor controlling irreversible quality loss in dried foods. The study suggests using re-hydration performance and SEM imaging as diagnostic tools to assess internal drying damage and to guide process conditions that minimize irreversible collapse.

Keywords: Cell damage, De-hydration, Hot-air drying, Re-hydration, Scanning Electron Microscopy

**AGRI-ECONOMICS, ENTREPRENEURSHIP
AND EXTENSION FOR AGRICULTURE**

FACTORS INFLUENCING PADDY FARMERS' ATTITUDES TOWARD CROP INSURANCE IN KANTALE DS DIVISION

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Abstract

Paddy, the staple food crop of Sri Lanka, plays a vital role in food security and rural livelihoods, particularly among smallholder farmers who depend on rice cultivation as their primary source of income. However, limited empirical evidence exists on how socio-economic factors, production risks, and seasonal price variations jointly influence farmers' attitudes toward crop insurance at the farm level. This study was conducted in the Kantale DS Division of Trincomalee District to examine socio-economic characteristics, seasonal farm-gate price variations, production risks, and the influence of socio-economic factors on farmers' attitudes toward crop insurance. Primary data were collected from 100 paddy farmers in five major GN divisions with high paddy cultivation, selected from a total of 23 GN divisions, using structured questionnaires and personal interviews, supported by secondary sources. Descriptive statistics were used to analyze socio-economic characteristics, farm-gate prices, and cultivation risks, while multiple linear regression assessed the influence of selected socio-economic factors on attitudes towards crop insurance. The results showed that most farmers were male (98%) and married (93%), with an average age of 47 years, around 10 years of schooling, and nearly 29 years of farming experience. Farm-gate prices varied seasonally, ranging from Rs. 45–55/kg in the Maha season and Rs. 50–60/kg in the Yala season. Major production risks included pest attacks (75%), floods (66.7%), and drought (50%), while 62% experienced household-related constraints affecting cultivation. Regression analysis indicated that education and farming experience had a positive and significant effect on attitudes towards crop insurance, explaining 68.2% of the variation, whereas farmers' age, income, and family size were not significant predictors. The study concludes that farmers operate under considerable price fluctuations and production risks, as evidenced by seasonal price variations and high incidences of pest attacks, floods, and drought. Farmers' attitudes toward crop insurance are significantly influenced by education level and farming experience, while age, income, and family size show no significant effects. Therefore, it is recommended that crop insurance schemes be designed in line with farmer characteristics and prevailing risks to enhance the resilience of paddy farming households.

Keywords: Crop insurance, Farm-gate price, Paddy farming, Production risks, Socio-economic characteristics

EXPLORING THE ICT CAPABILITY AMONG EXTENSION OFFICERS OF WESTERN PROVINCE, SRI LANKA

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Abstract

Enhancing ICT capabilities of extension officers is vital for bridging knowledge gaps in Sri Lanka's agriculture sector. However, the high officer-to-farmer ratio (1:500–700) severely limits traditional outreach, leaving farmers more vulnerable to climate risks, pest outbreaks, and resource inefficiencies. Given that effective extension delivery relies heavily on officers' ICT capability, this research addresses the limited empirical evidence in this context. The objective of this study was to assess the level of ICT capability among Agricultural Instructors (AIs) in the food-crop sector of Western Province and to identify the factors influencing it using the Unified Theory of Acceptance and Use of Technology (UTAUT) and Sen's Capability Approach. A mixed-methods sequential explanatory design was employed. Data were collected through a census of the entire population of all 106 AIs in the province (85 valid responses, 80% response rate) using a questionnaire, one focus group discussion and seven key informant discussions. Analysis included descriptive statistics, development and validation of an 11-item ICT Capability Scale ($\alpha=0.862$), K-means clustering with ANOVA ($p<0.001$), multiple linear regression based on UTAUT, and thematic analysis guided by Sen's framework. The mean capability score was 3.64 (SD=0.68), with 55 % of officers showing moderate-to-high levels. Officers actively used ICTs for communication and information sharing but lagged in transformative roles. Communication tools dominated while advisory apps remained under-utilized. Expectancy was the strongest predictor of capability. Key barriers were high data costs, unreliable internet, excessive workload, and farmer digital literacy. Targeted training and improved facilitating conditions are recommended to shift officers from active to transformative ICT roles for resilient, smart extension services.

Keywords: Agricultural extension, Extension officers, ICT capabilities, Western Province Sri Lanka

SMART TECHNOLOGY ADOPTION, INTEGRATION, AND PERFORMANCE OUTCOMES IN SMALL AND MEDIUM-SCALE ENTERPRISES (SMES) IN SRI LANKA: A SYSTEMATIC LITERATURE REVIEW

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Abstract

Small and Medium-Scale Enterprises (SMEs) play a pivotal role in driving economic growth, innovation, and employment in developing economies, and in Sri Lanka, they constitute over 75% of enterprises, contributing more than 52% to the national economy. Despite their strategic importance, SMEs have historically underperformed due to structural constraints such as limited capital, inadequate infrastructure, restricted access to information, and insufficient technical expertise, which reduce competitiveness in increasingly digitalized markets. This study aims to identify the smart technologies adopted by Sri Lankan SMEs, to examine the drivers and barriers influencing technology adoption and integration and to evaluate the impact of smart technology utilization on enterprise performance. The PRISMA framework was conducted to examine smart technology adoption among SMEs in Sri Lanka. Literature published between 2010 and 2025 was retrieved from Google Scholar, Scopus, ScienceDirect, and institutional repositories using pre-defined search terms. A total of 46 records were identified, of which 15 duplicates were removed. Following title and abstract screening, 31 studies were assessed, and 26 studies met the inclusion criteria for final analysis. The findings indicate that smart technologies, including cloud computing, e-commerce platforms, digital payment systems, ERP systems, and IoT applications, enhance productivity, operational efficiency, market reach, and innovation capacity. Adoption is influenced by competitive pressures, government initiatives, customer expectations, and efficiency motives, whereas financial constraints, limited technical knowledge, poor infrastructure, organizational resistance, and cybersecurity concerns hinder effective utilization. Integration across business functions and leadership commitment are essential to realizing performance gains, while urban rural and sectoral disparities further affect adoption trends. Overall, smart technologies have the potential to transform SMEs operations, but sustainable benefits depend on improving digital literacy, managerial capacity, infrastructure, and strategic alignment, which are critical for strengthening SMEs competitiveness, fostering innovation, and contributing to national economic growth.

Keywords: Digital transformation, Small and medium enterprises (SMEs), Smart technologies

PRICE BEHAVIOR OF SELECTED VEGETABLES AND FRUITS: EVIDENCE FROM PELIYAGODA NEW MANNING MARKET

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Abstract

Price changes for vegetables and fruits have a substantial impact on agricultural marketing, farmer income, and consumer purchasing habits in Sri Lanka. However, limited researches have thoroughly explored the determinants influencing the price behavior of certain vegetables and fruits. The objective of this study was to examine the price behavior of selected vegetables and fruits at the Peliyagoda New Manning Market in Sri Lanka by identifying the major factors influencing price fluctuations. A mixed-method technique was used by integrating quantitative and qualitative data. Primary data were collected from 212 wholesale traders using structured questionnaire, while secondary data covering the period from 2015 to 2024 were gathered from Hector Kobbekaduwa Agrarian Research & Training Institute (HARTI), Department of Meteorology, Sri Lanka and the Department of Agriculture, Sri Lanka. Price index, correlation, regression, and market margin analyses were conducted using MS Excel and IBM SPSS statistics version 25. The findings demonstrated clear seasonal price patterns, with prices increasing within off-season periods and decreasing throughout highest production seasons. Pineapple, tomato, and green chilli demonstrated high price variability, while Ambul banana, carrot, brinjal, and green bean demonstrated relatively steady prices by the selected vegetables and fruits. Correlation analysis demonstrated a weak relationship between rainfall and price changes. Regression analysis indicated that seasonality, demand shift, transport costs, and weather factor (rainfall) significantly affected price fluctuations. Therefore, understanding the price behaviour of selected vegetables and fruits is essential for improving market planning, policy formulation, and decision-making in the agricultural sector.

Keywords: Agricultural marketing, Market margin, Peliyagoda new manning market, Price fluctuation, Seasonality

FARMER'S PERCEPTION AND WILLINGNESS TO ADOPT NATURAL FARMING PRACTICES IN MORONTHUDUWA, KALUTARA DISTRICT, SRI LANKA

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Abstract

Natural Farming (NF) is increasingly promoted as a sustainable alternative to chemical-intensive agriculture. However, empirical evidence on its adoption dynamics in Sri Lanka remains scarce. This study investigates the determinants of NF adoption in Moronthuduwa, Kalutara District, with a focus on perception, willingness, socio-economic factors, knowledge, environmental conditions, and perceived barriers. Primary data were obtained from 150 farmers using a structured questionnaire and analyzed through correlation and multiple regression models. The regression results demonstrate strong explanatory power ($R^2=0.910$), indicating that the model accounts for a substantial proportion of variation in adoption behavior. Perception, socio-economic factors, knowledge, and perceived barriers exhibit statistically significant effects ($p<0.05$), whereas willingness and environmental factors are not significant predictors. The insignificance of willingness highlights a pronounced intention–behavior gap, suggesting that motivational factors alone are insufficient in the absence of enabling conditions. The findings reinforce key propositions of the Theory of Planned Behavior and Diffusion of Innovations, underscoring the critical role of cognitive, informational, and structural determinants in shaping adoption decisions. From a policy perspective, the results emphasize the need for targeted interventions, including strengthened extension systems, knowledge dissemination, and barrier reduction through institutional and market support mechanisms. The study concludes that enhancing adaptive capacity and reducing systemic constraints are essential for scaling NF adoption and advancing sustainable agricultural transitions in Sri Lanka.

Keywords: Adoption, Farmer perception, Natural farming, Socio-economic factors, Sustainable agriculture

PERCEIVED EFFECTIVENESS OF AGRICULTURAL EXTENSION SERVICES AMONG SUGARCANE FARMERS IN MONARAGALA DISTRICT, SRI LANKA

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Abstract

Smallholder sugarcane farmers in Monaragala District, Sri Lanka depend on agricultural extension services to transition from traditional to evidence-based cultivation practices, yet the factors shaping their perceived effectiveness remain poorly characterized. This cross-sectional quantitative study assessed nine thematic factors among 108 sugarcane farmers using a validated, 27-item Sinhala-language questionnaire (Cronbach alpha=0.733) administered via snowball sampling; data were analyzed using descriptive statistics, Spearman and Pearson bivariate correlations, and chi-square tests. The economic baseline emerged as the primary structural constraint (M=2.41), while peer-to-peer networks (M=3.26) and farmer attitudes towards modernization (M=3.08) were the strongest enabling dimensions, against a grand mean perceived effectiveness of M=2.83. Digital literacy positively correlated with farmer interest ($\rho=0.285$, $p=0.003$), satisfaction ($\rho=0.262$, $p=0.006$), and attitude ($\rho=0.229$, $p=0.017$), while age was negatively correlated with digital literacy ($r=-0.336$, $p<0.001$). Preference for high-contact advisory engagement positively correlated with farmer interest ($\rho=0.394$, $p<0.001$) and attitude ($\rho=0.192$, $p=0.047$). Optimizing extension effectiveness in this context requires integrating economic support mechanisms with technical advisory delivery, investing in digital literacy training for older farmer cohorts, and formalizing existing peer network structures to amplify institutional extension reach.

Keywords: Agricultural extension services, Digital literacy, Peer-to-peer networks, Perceived effectiveness, Smallholder sugarcane farmers

ASSESSING THE DETERMINANTS OF YOUTH ENGAGEMENT IN CINNAMON CULTIVATION AND PROCESSING: A CASE STUDY OF KAMBURUPITIYA, SRI LANKA

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Abstract

This study examines the determinants of youth engagement in cinnamon (*Cinnamomum verum*) cultivation and processing in Kamburupitiya Divisional Secretariat Division, Matara, Sri Lanka. Despite its economic importance, youth participation in the cinnamon sector remains limited. This is particularly significant because cinnamon industry relies on specialised traditional knowledge and skills transmitted across generations, for maintaining the quality and global competitiveness of Ceylon cinnamon. Adopting a quantitative case study approach, data were collected through structured questionnaires administered to 50 youths aged 15–29. Participants were selected using snowball sampling. The data were analysed using descriptive statistics, the Kruskal–Wallis H test, and regression analysis in IBM SPSS version 25. The regression model evaluated the effects of technical, organizational, and environmental barriers on youth engagement, with all constructs demonstrating satisfactory reliability (Cronbach’s $\alpha=0.801–0.876$). The findings reveal that all respondents originated from cinnamon-related households, and most possessed work experience. While family tradition (42%) and personal interest (38%) were key motivators, 70% expressed reluctance to remain in the industry long term. Over half of the respondents lacked formal training, and most expressed a demand for advanced cultivation training. No significant differences in awareness levels were observed across age, education, and employment status groups ($p>0.05$). In contrast, the regression model explained 72.5% of variance in youth engagement ($R^2=0.725$). Among the predictors, technical barriers had the greatest influence ($\beta=0.493$, $p<0.001$), followed by environmental barriers ($\beta=0.445$, $p<0.001$) and organizational barriers ($\beta=0.358$, $p<0.001$). The study concludes that enhancing youth participation in the cinnamon sector requires interventions focused on capacity building, improved extension services, and stronger institutional and financial support. Nevertheless, the findings should be interpreted with caution, as the exclusive inclusion of youths from cinnamon-related households limits the generalizability of the results.

Keywords: Agricultural participation, Cinnamon cultivation, Sri Lanka, Training needs, Youth engagement

AWARENESS OF HYGIENIC MILK PRODUCTION PRACTICES AMONG SMALL-SCALE DAIRY FARMERS IN AGUNAKOLAPELESSA, SRI LANKA

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Abstract

Unhygienic milking practices may cause microbial contamination and the transmission of milk-borne diseases to humans. Although proper hygiene can reduce these risks, there is limited evidence on whether dairy farmers are aware of such practices. Therefore, this study aims to assess the level of hygiene awareness among small-scale dairy farmers in the Agunakolapelessa Divisional Secretariat, Hambantota district, Sri Lanka. A quantitative cross-sectional research design was adopted using a semi-structured questionnaire given to 141 randomly selected small-scale dairy farmers, to evaluate how farm characteristics, economic factors, regulatory and policy factors, market factors, technological factors, environmental factors, social and cultural factors, and access to information and training influence awareness of hygiene practices among farmers. Data were analyzed using IBM SPSS Statistics (version 25) software. Correlation analysis indicated that farm characteristics (0.429), economic factors (0.290), market factors (0.416), technological factors (0.295), environmental factors (0.235), social and cultural factors (0.643), and access to information and training (0.743) had significant ($p < 0.05$) positive relationships with awareness of hygiene practices. The regression model represented 61.6% of the variation in hygiene awareness ($R^2 = 0.616$) and was statistically significant overall ($F = 26.496$, $p < 0.001$). According to regression analysis, market factors ($\beta = 0.223$, $p = 0.020$), social and cultural factors ($\beta = 0.235$, $p = 0.003$), and access to information and training ($\beta = 0.515$, $p = 0.000$) had statistically significant ($p < 0.05$) positive effects on awareness of hygiene practices. This shows that farmers with better access to information and training tend to have higher levels of hygiene awareness. Therefore, the study highlights that expanding access to information, farmer training programs and, extension services are essential to improve hygienic milk production practices among small-scale dairy farmers in Agunakolapelessa, Sri Lanka. The findings also provide valuable insights to policy makers and extension agencies to improve their strategies for enhancing milking hygiene.

Keywords: Extension services, Farmer training, Hygiene awareness, Milk quality

**ADVANCED TECHNOLOGIES IN
LIVESTOCK AND AQUATIC PRODUCTION**

ISOLATION AND IDENTIFICATION OF RARE *Vibrio* SPECIES FROM WATER SAMPLES WITH ELEVATED MORTALITY OF (*Hippocampus kuda*) IN AN ORNAMENTAL FISH FARM IN NEGOMBO, SRI LANKA

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Abstract

Vibriosis remains a major constraint in marine ornamental aquaculture, particularly during the larval rearing of *Hippocampus kuda*, where disease outbreaks frequently result in high mortality. While commonly reported pathogens such as *Vibrio alginolyticus*, *V. harveyi*, and *V. splendidus* have been extensively studied, the occurrence and potential role of less frequently reported *Vibrio* species in seahorse hatchery systems remain poorly understood. Therefore, this study aimed to isolate and characterize *Vibrio* species associated with high larval mortality in an ornamental fish hatchery in Negombo, Sri Lanka. Water samples were aseptically collected from larval rearing tanks exhibiting elevated mortality. Samples were enriched in alkaline peptone water and cultured on Thiosulfate Citrate Bile Sucrose (TCBS) agar and Tryptone Soy Agar (TSA). Distinct colonies were purified through repeated subculturing. Bacterial isolates were identified based on morphological characteristics and a comprehensive suite of biochemical tests, following standard taxonomic protocols. Three less frequently reported *Vibrio* species, including *Vibrio mimicus*, *Vibrio fluvialis*, and *Vibrio pelagius*, were identified. All isolates were Gram-negative, motile, curved rods, and exhibited oxidase and catalase positivity, growth in 6% NaCl, and glucose fermentation. Species differentiation was achieved using detailed biochemical profiling, including oxidative/fermentative metabolism, nitrate reduction, indole production, citrate utilization, decarboxylase activities, and enzymatic assays. The occurrence of these *Vibrio* species in high-mortality larval tanks suggests a potential association with disease events and indicates a broader diversity of bacterial communities in seahorse hatchery systems than previously recognized. However, the absence of molecular confirmation and pathogenicity assays limits definitive conclusions regarding their etiological role. These findings highlight the need for comprehensive microbial monitoring, integration of molecular diagnostic approaches, and improved biosecurity practices to mitigate disease risks and enhance larval survival in ornamental aquaculture.

Keywords: *Hippocampus kuda*, Ornamental aquaculture, *Vibrio* species

BREED-WISE VARIATION IN MILK YIELD AND PRODUCTION GAPS IN DAIRY CATTLE UNDER TROPICAL SMALLHOLDER SYSTEMS IN JAFFNA

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Abstract

The dairy sector in Jaffna, Sri Lanka, exhibits both promising potential and significant challenges that influence its overall sustainability. This study aimed to evaluate the production performance of various dairy breeds in Jaffna, including Jersey, Friesian, Sahiwal, Girolando, Sindhi, and local crosses. The study was conducted from January to September 2025 through surveys and interviews using pre-structured questionnaires, supplemented with individual cow records. The data were collected from 248 farms covering 265 animals using a stratified random sampling design. Key production parameters, daily milk yield and lactation length, were recorded, and total lactation milk yield was evaluated in comparison with established standards. One-sample t-test and descriptive statistics were performed which revealed substantial variation in performance: Jersey (2271.2 ± 1310.8 L), Girolando (2498.4 ± 1129.4 L), and Sindhi crosses (2469.9 ± 1127.2 L) achieved the target lactation yield (Jersey: 1,747–2,427 L; Girolando: 2,427–3,398 L; Sindhi crosses: 1,747–2,718 L) ($p > 0.05$) with the latter two recording the highest average total lactation yields among the breeds. However, their maximum breed-specific production potential was not fully realized. Sahiwal (2096 ± 219.9 L) exceeded the target lactation yield ($p < 0.05$), demonstrating greater resilience under local tropical conditions. In contrast, Friesian crosses (2191.5 ± 1164.2 L) exhibited suboptimal performance ($p < 0.05$), which could be associated with poor adaptability to the tropical climate of the study area. The low performance of indigenous cattle (510.94 ± 172.15 L) ($p < 0.05$) may be attributed to their lower genetic potential compared to exotic breeds. Although most breeds performed within the established target ranges, substantial potential remains to achieve the upper limits of milk production. These findings reveal a consistent gap between realized and genetic potential, primarily driven by management constraints rather than breed limitation. Therefore, the study highlights the importance of strategic crossbreeding, optimized feeding, and enhanced health and housing practices to narrow the gap between achieved and target yields. The implementation of these measures will improve the productive potential of dairy cattle breeds in the Jaffna District, thereby contributing to an enhancement in national milk production.

Keywords: Breed, Jersey, Lactation yield, Nutrition, Production potential

UTILIZATION OF POULTRY BY-PRODUCT MEAL AS A PARTIAL REPLACEMENT FOR FISHMEAL IN DIETS OF GIFT TILAPIA (*Oreochromis niloticus*) AND ITS EFFECTS ON GROWTH PERFORMANCE AND FEED UTILIZATION

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Abstract

Soaring price and unsustainability lead to explore optimal replacements for Fish Meal (FM) in animal feed industry. Poultry Sludge Waste (PSW) is emerging as a sustainable and economically viable alternative to FM, as it can be produced locally. Simultaneously, PSW has been identified as a sustainable and cost-effective aquafeed ingredient. Therefore, considering the economical and nutritional benefits of PSW, this experiment was conducted using *Oreochromis niloticus* (GIFT tilapia) fry to evaluate the feasibility of replacing FM with PSW in their diet without affecting growth performance. In a forty-seven-day experiment, the fish were divided into nine fish tanks, each containing 30 fish. Iso-protein ($35.13 \pm 0.02\%$, dry weight basis) and iso-energetic ($18.2 \pm 0.2 \text{ kJg}^{-1}$) diets were fed, and FM was used as the main animal protein source in the control. The other two treatments were fed diets containing 10% and 20% PSW, replacing FM. Thus, the Completely Randomized Design was followed with three treatments and three replicates. Moreover, soymeal, corn, rice polish, fish oil, vitamin-mineral mixture, and CMC were used as ingredients, in addition to FM, and PSW. This study confirmed that PSW can be replaced FM in the diet of *O. niloticus* fry without affecting growth. According to Tukey's test, there were no significant differences ($p > 0.05$) in initial and final body weight, weight gain, relative weight gain and specific growth rate among all treatments. Since the survival rate was high, the tested diet did not adversely affect the survival of *O. niloticus* fry. In conclusion, PSW can partially replace FM, at a ratio of 10%-20%, However, further studies are recommended to confirm the effects of these diets on liver and carcass quality and overall health of the fry.

Keywords: Fishmeal replacement, Novel feed ingredients, *Oreochromis niloticus*, Sustainable aqua feed

EVALUATION OF REPRODUCTIVE EFFICIENCY OF DAIRY CATTLE IN JAFFNA DISTRICT AND ITS KEY INFLUENCING FACTORS

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Abstract

Dairy cattle productivity is largely determined by their reproductive efficiency. This study aimed to assess the reproductive performance of dairy cattle in the Jaffna District, focusing on management systems, production scale, and daily milk yield as influencing factors. Data were collected from 265 animals using a pretested structured questionnaire administered between 2022 and 2024. Reproductive indices recorded included Age at First Service (AFS), Age at First Calving (AFC), Number of Services per Conception (NSC), Calving Interval (CI) and Days Open (DO), along with management and production data. All data were analyzed using descriptive statistics and inferential tests to compare reproductive performance across different management, production systems, and daily milk production. The Kruskal–Wallis test was performed to evaluate differences in median values among groups at a significance level of $p=0.05$. Pairwise comparisons between groups were conducted using Dunn’s post hoc test at $p=0.05$. The findings revealed that reproductive performance is strongly influenced by management system, production scale, and milk yield. Large-scale and intensive farms exhibited superior fertility and a higher milk yield was linked to enhanced reproductive performance, suggesting that effective management strategies may help to mitigate the negative effects of high production demands on reproductive efficiency. These results provide valuable insights into fertility trends in the study area and indicate that improving management systems toward intensive, large-scale operations can optimize breeding efficiency. The study highlights the critical role of integrated strategies in sustaining productivity and reproductive performance in Jaffna dairy herds.

Keywords: Artificial insemination, Calving, Conception, Fertility, Reproductive traits



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