



Proceedings of the

11th Annual Research Symposium 2019

“Greener Agriculture for Sustainable Environment”

**Organized by the
Faculty of Agriculture
Rajarata University of Sri Lanka**

**Co-organized by
Ministry of Science, Technology, Research, Skills Development &
Vocational Training and Kandyan Heritage
Sri Lanka**

Proceedings of the 11th Annual Research Symposium 2019

Faculty of Agriculture, Rajarata University of Sri Lanka

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FOREWORD

It is with great pleasure that I write this Foreword to the Proceedings of the 11th Annual Research Symposium (ARS) 2019 of the Faculty of Agriculture, Rajarata University of Sri Lanka. It has been a real honour and privilege to serve as the Editor-in-Chief of the ARS 2019. Over the past 11 years, the ARS has particularly encouraged the interactions of research students and develops linkages with more established academic community and industry to exchange research findings and envision potential solutions to current issues in the areas related to agriculture. The theme of ARS this year is “*Greener Agriculture for Sustainable Environment*” focusing on the attempts to introduce strategies, practices, and policies for green growth in agriculture while addressing specific environmental challenges.



This year the proceedings consists of 82 research abstracts and an invited keynote address titled “*The Emerging Role of Geoenvironmental Engineering: Appropriate Technologies for Environmental Pollution Control and Infrastructure Development*”. The abstracts contribute to the most recent scientific knowledge in eight disciplines of agriculture namely, Agricultural Engineering, Environmental Soil Management, Agricultural Economics and Extension, Agricultural Systems Management, Animal Production and Technology, Food and Postharvest Technology, Agricultural Biology, and Crop Science.

The quality of the proceedings is continued to grow and reflects the nature of researches conducted, procedures adopted, and the dedication and efforts of numerous contributors. This year an online abstract submission system was introduced to provide opportunities for students to get familiarized with a virtual environment that creates an interactive and immersive experience. Each abstract was reviewed by two reviewers other than student's supervisors.

I take this opportunity to convey my sincere gratitude to Dr. B.A. Karunaratne, the Vice Chancellor of the Rajarata University of Sri Lanka, Dr. A.M.J.B. Adikari, the Dean of the Faculty of Agriculture, and Dr. D.M.S.H. Dissanayake, the Coordinator of 11th ARS for their valuable contributions in assembling a high-quality symposium. This proceedings would not have been possible without the enthusiastic and hard work of the department coordinators of the proceedings committee. I'm indeed grateful for their untiring efforts. The success of this proceedings is built primarily on four groups; the undergraduate students and their supervisors who authored high caliber scholarly work, the reviewers of the abstracts, the editorial board, and the publication committee. I seize this opportunity to thank all of them and express my sincere appreciation for their invaluable contribution and efforts in producing a quality proceeding. Finally, on behalf of the editorial board, I acknowledge all those who assisted in numerous ways to complete the proceedings of the 11th ARS successfully.

Dr. (Mrs.) S.N. Dissanayake
Editor-in- Chief/ 11th ARS
Faculty of Agriculture, Rajarata University of Sri Lanka

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MESSAGE FROM THE VICE CHANCELLOR



I warmly extend my heartiest gratitude for the 11th Annual Research Symposium 2019 of the Faculty of Agriculture, Rajarata University of Sri Lanka. Research is the link among Universities, Industries and Research Institutes. The collaboration among them is mutually beneficial for both parties leading to sustainability of collaborative programs. It also has a clear potential to make a significant contribution to the quality of higher education. Therefore, this symposium would provide a platform to present and publish research work carried out by final year undergraduates under the guidance of academic staff and the outside subject experts. Most of the researches conducted are applied research that address most of the issues directly related to the agriculture development of the country. It is evident that the quality of the research and symposium proceedings have reached a commendable level showing the commitment of the academic staff and the students to develop the research culture in the Faculty.

I would also like to extend my sincere gratitude to Dr. A. M. J. B. Adikari, Dean of the Faculty of Agriculture, Dr. (Mrs.) D.M.S.H. Dissanayaka, Coordinator of the symposium, Dr. (Mrs.) S. N. Dissanayake, the Editor-in-chief of the proceedings of the 11th Annual Research Symposium 2019, all academics and non-academics of the Faculty of Agriculture for the immense support, commitment and cooperation for making this event successful.

Finally, I extend best wishes for those who present their research findings at the 11th Annual Research Symposium, 2019.

Dr. B. A. Karunaratne
Vice Chancellor
Rajarata University of Sri Lanka

MESSAGE FROM THE DEAN



It is a great pleasure to issue this message on the occasion of 11th Annual Research Symposium (ARS), 2019 of the Faculty of Agriculture, the Rajarata University of Sri Lanka on “*Greener Agriculture for Sustainable Environment*”. Annual Research Symposium of the faculty is an annual event in the academic calendar of the Faculty and has been a great success in last several years with high quality presentations and participation of academics, industry personnel, undergraduates, and scientists from different research institutions.

The ARS 2019 has a great importance to the Faculty mainly because the research outcomes of the graduating students are disseminated to the public after six months of research work. I sincerely believe the experience that students gain, and the partnership strengthen in participating the research session will brighten their path to the challenging future. The proceedings of this year symposium consists of research abstracts presented by 82 graduating students of the faculty. The quality of the abstracts has been maintained by reviewing thoroughly and assessed by a panel of experienced editorial board.

I would like to extend my gratitude to Dr. (Mrs.). D.M.S.H. Dissanayaka, Coordinator of the symposium and Dr. (Mrs.). S.N. Dissanayake, Editor in-chief of the proceedings of the 11th Annual Research Symposium 2019 and other committee members for the tremendous effort for the success of the symposium.

As the Dean of the Faculty, I also wish to convey my sincere gratitude to the heads of the departments, academic and non-academic staff of the Faculty of Agriculture for extending their fullest support and corporation to show up the ARS 2019 for the 11th consecutive year. I also congratulate the graduating students and would like to place a special remark to Dr. B.A. Karunaratne, Vice Chancellor of the University for his moral support and inspirations to complete the event successfully. I also would like to express my sincere gratitude to the university, Ministry of Science, Technology and Research, sponsors and contributors for the financial assistance to meet the expenses of the symposium.

I wish 11th Annual Research Symposium 2019 would be a great success.

Dr. A.M.J.B. Adikari
Dean/Faculty of Agriculture
Rajarata University of Sri Lanka

MESSAGE FROM THE COORDINATOR

It is with great privilege and pleasure I convey this message to the proceedings of the 11th Annual Research Symposium 2019, Faculty of Agriculture, Rajarata University of Sri Lanka organized under the theme “*Greener Agriculture for Sustainable Environment*”. The annual research symposium focuses on dissemination of research problems, problem solutions, and insights on new challenges facing in the agriculture and related disciplines. The event will be delighted by a keynote speech and an invited speech by two internationally recognized researchers from Japan and People’s Republic of China followed by eight parallel technical tracks consisting of 82 oral presentations. Moreover, two pre-symposium workshops have been conducted on “Preparing Successful 3MT Presentation” and “Effective Presentation Skills”.



I would like to take this opportunity to convey my profound gratitude to Dr. B.A. Karunaratne, Vice Chancellor of the Rajarata University of Sri Lanka and Dr. A.M.J.B. Adikari, Dean of the Faculty of Agriculture on their guidance and fullest support in organizing this important event. I also express my sincere thanks to the keynote speaker, Prof. Ken Kawamoto, Graduate School of Science and Engineering, Saitama University, Japan for accepting our invitation to deliver the keynote speech and travelling here from Japan at his own expenses. Also I acknowledge Prof. Uromi Manage Goodale, Guangxi University of China for conducting a collaborative research with one of our undergraduate for the first time. All the chairpersons and members of different sub-committees have done a wonderful job in organizing this symposium. Therefore, my heartfelt appreciation also goes to all the members of the academic staff, the administrative staff and the non-academic staff in the faculty. Further, I would like to extend my sincere thanks to all authors and presenters at the 11th Annual Research Symposium who are the major contributors in this event. Also, I extend deep gratitude to the members of in the editorial committee, reviewers and all the panelists for their valuable comments and views on current research topics. I acknowledge Dr. (Mrs.) S.N. Dissanayake, the Editor-in-Chief of the conference for her outstanding contribution and Mr. P.D. Kahandage, for his significant effort on bringing this publication to the present format within a short period of time. Also, I thank Mr. R.A.A.S. Rathnayake for his dedication and bigger workload carried out as the Secretary of this symposium.

Financial assistance to this event was given by many generous contributors and I am grateful to all the sponsors for their generous support. Special thanks to the Co-sponsor of this event, Ministry of Science, Technology and Research.

I would like to congratulate all the final year undergraduates who become graduates from today and wish all the best in their future endeavors. Finally, I wish a successful symposium.

Dr. (Mrs.) D.M.S.H. Dissanayake
Coordinator/ 11th ARS
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KEYNOTE ADDRESS

THE EMERGING ROLE OF GEOENVIRONMENTAL ENGINEERING: APPROPRIATE TECHNOLOGIES FOR ENVIRONMENTAL POLLUTION CONTROL AND INFRASTRUCTURE DEVELOPMENT

By

Ken Kawamoto

Professor, Graduate School of Science and Engineering, Saitama University,
Japan

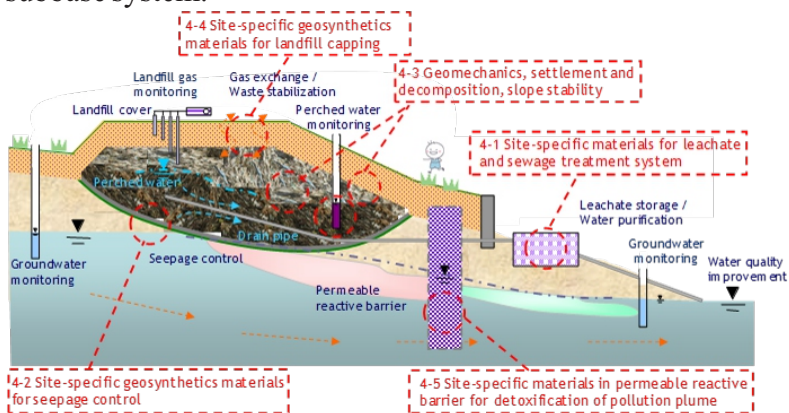
Open dumping of waste is the most common way of disposing municipal solid waste in developing countries due to the lower cost over the other waste management techniques. In the case of Sri Lanka, most of waste landfills are operated as unmanaged and uncontrolled open dumpsites as a result of lack of engineered technologies and capacities of operation and maintenance. Due to rapid urbanization and increase in population, amount of solid waste generation is expected to increase rapidly in upcoming years and environmentally sound waste landfilling is highly required in Sri Lanka. Open dumping of solid waste under unsanitary conditions causes various kinds of problems: 1) Damage to human health surrounding the dumping sites (water-born infectious diseases), 2) Environmental pollution (water, air, soil, and sea), 3) Disaster (landslide, explosion), 4) Global warming (emission of greenhouse gases), and so on. In order to avoid and prevent those problems, appropriate techniques for pollution control and environmental restoration should be adopted.

On the other hand, with rapid urbanization on all fronts, much construction is conducted everywhere in developing countries, especially in big cities. All these activities, new construction, renovation, and demolition of buildings and structures, generate huge amounts of waste, called construction and demolition waste (CDW). In Vietnam, for example, the total municipal solid waste generation was about 60 thousand tons/day on average, of which the CDW waste accounts for 10–12% of total solid waste according to the State of the Environment report of 2011 on solid waste management issued by Ministry of Natural Resources and Environment. In order to maximize the potential positive impacts but at the same time to minimize the negative effects of modernization and industrialization, it is necessary 1) to take immediate measures to protect the environment, 2) to promote recycling of CDW, and 3) to reduce the use of natural resources for environmentally-sustainable infrastructure development.

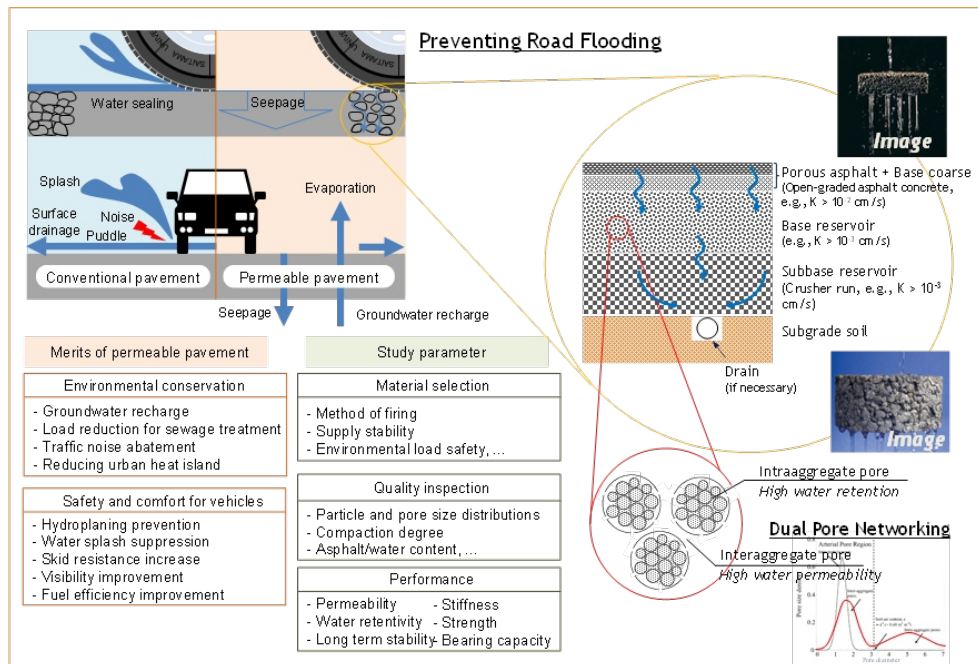
Based on the agreement between Sri Lanka and Japan, the JST-JICA SATREPS (Science and Technology Research Partnership for Sustainable Development) project entitled “Development of pollution control and environmental restoration technologies of waste landfill sites taking into account geographical characteristics in Sri Lanka” has been carried out from 2011 to 2016.

And, based on the agreement between Vietnam and Japan, the JST-JICA SATREPS project entitled “Establishment of Environmentally Sound Management of Construction and Demolition Waste and Its Wise Utilization for Environmental Pollution Control and for New Recycled Construction Materials in Vietnam” has begun from 2018 and will continue until 2022. One of main activities in the both SATREPS project is to develop pollution control and environmental restoration techniques with site-specific, low cost, sustainable, environmentally friendly, and engineered/easy-construction. In this keynote address, some of developed and developing techniques with the use of locally available geo- and bio-materials and industrial by-products are introduced, and it is emphasized the emerging role of Geoenvironmental Engineering for developing those techniques.

For the pollution control and environmental restoration techniques for waste landfill sites, the Sri Lankan SATREPS project mainly targets five components which are necessary for upgrading open waste dumpsites into engineered and sanitary waste landfills; 1) Leachate treatment, 2) Surface lining and seepage control, 3) Geomechanics and slope stability, 4) Landfill capping, and 5) Permeable reactive barrier (PRB) for in-situ contaminant treatment of groundwater. In the project, locally-available geo- and bio-materials are encouraged to use for proposing applicable and durable techniques in Sri Lanka. Effectiveness and performance of developed appropriate techniques have been evaluated not only by laboratory tests but also by field experiments. Besides, part of newly developed techniques have been adopted in the follow-up JICA technical cooperation project in Sri Lanka; 1) PRB and leachate treatment techniques at Kurunegala waste landfill site and 2) bottom liner and leachate treatment techniques at newly-constructed semi-engineered waste landfill site in Kataragama, Sri Lanka. On the other hand, in order to develop new techniques utilizing recycled materials produced from CDW and industrial by-products, the Vietnam SATREPS project targets 1) Treatment technique for heavy metal-contaminated/oil-polluted water, and 2) Permeable road pavement technique with the high water-retentive road base/subbase system.



Five research components to develop site-specific pollution control and remediation techniques at municipal solid waste landfills (adopted from “Guide for Sustainable Planning, Management and Pollution Control of Waste Landfills in Sri Lanka 2011-2016. SATREPS Project, May 2018)



Concept on the development of new permeable road pavement system utilizing recycled CDW and industrial by-product in Vietnam (Adopted from JICA Application form for Japan's Technical Cooperation. July 2015)

See more details scientific evidence and backup for newly-developed techniques and role of Geo-environmental Engineering in academic publications:

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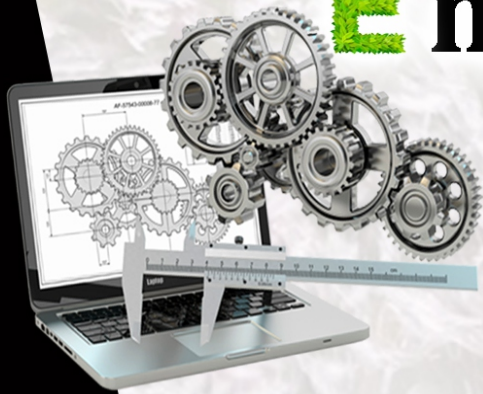
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Agricultural Engineering



SMALL SCALE CONSTRUCTED WETLAND UNITS FOR DOMESTIC GREYWATER TREATMENT

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Constructed wetlands (CWs) are widely used environmental friendly greywater treatment method. However, requirement of larger land area is a major limitation for its use. Small scale CW units can be the best option for domestic greywater treatment since it reserves limited land area. This study aimed to check the feasibility of using small scale CW units for domestic wastewater treatment. The CW units were constructed using plastic containers (55x30x30 cm). Eight treatments; in combination of selected wetland plants *Vetiver* (*Vetivria zizanioides*), *Kangkung* (*Ipomoea aquatica*), *Kohila* (*Lasia spinosa*) were tested and soil without amendments were served as a control. Wastewater were synthesized, similar to the domestic greywater and fed into CW units at the rate of 0.51 h⁻¹. Hydraulic retention time was 63 hours. Phosphate Phosphorous (PO₄⁻³-P), Nitrate Nitrogen (NO₃⁻-N), Ammonium Nitrogen (NH₄⁺-N), Total Dissolve Solids (TDS), pH, Electrical Conductivity (EC) and certain trace elements were monitored both in influent and effluent in two week intervals for two months. The experiment was conducted in a completely randomized design with three replicates. Results revealed that each combination of wetland plants recorded an increasing pollutant (NH₄⁺-N, NO₃⁻-N, PO₄⁻³-P, TDS, pH, EC and trace elements) removal efficiencies (REs) throughout the monitoring period. Plant combination of *Kangkung*, *Kohila* and *Vetiver* showed significantly ($p < 0.05$) higher performance in removal of NH₄⁺-N, NO₃⁻-N, PO₄⁻³-P with the REs of 62%, 66% and 65% respectively. After the treatment process; in all treatments, trace elements, pH, EC and TDS of the effluents were ranged around the permissible level following the general standards for wastewater. The overall results conclude that small scale CW units are a viable technology for greywater treatment at domestic level with the combination of *Kangkung*, *Kohila* and *Vetiver*. Further studies are recommended for concrete conclusion.

Keywords: Constructed wetlands, Greywater treatment, Removal efficiencies, Wetland plants

THE IMPACT OF WATER QUALITY ON TASTE PROFILE OF MADE TEA IN SRI LANKA

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Type of water used for brewing tea make a difference in taste profile of made tea, color and, aroma despite of tea with same quality. Hence, quality of water plays a major role in making tea infusions. This study was conducted to determine the influence of water quality on the taste profile of made tea. Water samples were collected from most commonly used potable water sources in Sri Lanka, i.e. well water from selected locations (*Nikaweratiya, Matale, Anuradhapura, Kebithigollewa*), RO filtered water, tap water and mineral water. Distilled water was used as the control. Hardness, pH, Total Alkalinity, PO_4^{3-} -P, Cl^- , F^- , NO_3^- , Total Dissolved Solid (TDS), and Dissolved Oxygen of each water source were tested. Then infusions of black tea, green tea and flavored tea were prepared and the sensory evaluation was performed according to the ISO 3103-1980 standards by a standard tasting panel. Data were analyzed using SAS 9.0 software. According to the results, highest overall acceptability for black tea was recorded for the infusions made from distilled water, *Kabithigollewa* well water and RO filtered water. These water samples reported lower values of TDS, Cl^- , and hardness among the other water sources. Highest overall acceptance for flavored tea and green tea was recorded from mineral water attributed to moderate values for almost all the measured water quality parameters. However, the worst taste profile was reported for all three types of tea infusions made by using well water from *Anuradhapura*. Hardness, alkalinity, TDS, Cl^- and F^- contents of water samples collected from *Anuradhapura* were reported highest values compared to others. Therefore, this study concludes that the quality of water is significantly affecting on the taste profile of tea intrusions and further studies are recommended with water samples from all over the island to test its impacts on the tea taste.

Keywords: Sensory evaluation, Taste profile, Tea, Water quality

EFFECT OF AERATION ON PRODUCTION RATE AND NUTRITIONAL LEVEL OF ENRICHED COMPOST

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Agricultural activities tend to generate a substantial volume of animal and crop residues. Composting is the most economical and ecologically sustainable option to manage farmyard waste. However, it takes approximately three months to complete decomposition and contains lower plant nutrients percentage compared to inorganic fertilizers. This study aimed to reduce the decomposition time and improve nutrients content of compost. Aerobic decomposition was enhanced by aeration inside the pile using a blower with $0.5 \text{ Lmin}^{-1}\text{kg}^{-1}$ air flow. Paddy straw, poultry manure, goat manure, cattle manure, and paddy husk ash were mixed in 3:1:1:1:1 ratio respectively as the raw materials and 3% of *Eppawala* rock phosphate was added to the mixture in weight basis. Six piles; (150x100x80 cm) were prepared and 3 piles were aerated for six hours per day. Other 3 piles were left to decompose under ambient condition as the controls. According to the results, aerated and control piles took 35 days and 65 days respectively to complete the decomposition. Total N, available P, exchangeable K, C/N ratio, pH, EC, and (Cation Exchange Capacity) CEC were analysed in compost samples from aerated (after 35 days) and controls, and the results were, 20.5 gkg^{-1} , 1.8 gkg^{-1} , 10.4 gkg^{-1} , 7, 8.8, 4.3 mScm^{-1} , 19.3 cmolkg^{-1} and 17.8 gkg^{-1} , 1.5 gkg^{-1} , 9.9 gkg^{-1} , 8.5, 8.8, 3.64 mScm^{-1} , 21.3 cmolkg^{-1} respectively. Data were analysed using SAS 9.0 software with 95% confidence interval. The results revealed that, there is a significant increment in total N, exchangeable K, C/N ratio, EC, and CEC in aerated piles compared to controls. And the nutrient composition of both methods were significantly higher than commercial compost. Therefore, it can be concluded that, decomposition time can be effectively reduced and nutrient level can be increased by artificial aeration and nutrient enrichment respectively. However, further studies are recommended to study the economic feasibility.

Keywords: Force air circulation, Enriched compost, Decomposition, Plant nutrients

DESIGN AND DEVELOPMENT OF A TWO-WHEEL TRACTOR COUPLED BUND PLASTERING AND CANAL (*kiwul-ela*) MAKING EQUIPMENT

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Rice (*Oryza sativa* L.) is the staple food and major crop in Sri Lanka. Improving rice cropping practices and production systems are required to enable a sustainability. Presently bund cleaning, plastering, and *kiwul-ela* constructing are done manually and there is no proper mechanical solution. Thus, this study was aimed to design and develop an appropriate bund plastering and *kiwul-ela* making equipment as a rear attachment to a walking type two-wheel tractor. Design, fabrication and testing were done in Faculty of Agriculture, Rajarata University of Sri Lanka. The main components of the equipment were bund plaster, bund cleaner, *kiwul-ela* maker, depth controller, and main frame. Mild steel box iron and sheets, galvanise pipe and rubber wheel were used to construct the prototype. Permanent and non-permanent fastening methods were used. The total weight, length and width of the equipment were 38.85 kg, 1.2 m and 0.92 m, respectively. The preliminary tests were conducted to evaluate the performance of the prototype and modified using the classical approach of farm machinery design and development. After primary land preparation, a low land puddle paddy field with an average bulk density of 2.144 gcm^{-3} and moisture content of 14.81% were used as the test field. The prototype showed significantly higher comparative performances; 93.93% of time saving and 64.4% of cost reduction over the manual method ($p < 0.05$). Further, prototype showed highly satisfactory field performances; operational speed 2.045 kmh^{-1} , draft force 49.08 N, plastering thickness $0.032 \pm 0.002 \text{ m}$, and height $0.21 \pm 0.02 \text{ m}$, theoretical field capacity $52.054 \times 10^{-3} \text{ hah}^{-1}$ and field efficiency 63.6%. Due to the higher performance of this bund cleaning, plastering and *kiwul-ela* making equipment, it could be recommended for paddy farmers. However, the plastering height could be further increased by modifying the mouldboard of this equipment.

Keywords: Bund cleaner, Bund plastering, *Kiwul-ela* making

DESIGN AND DEVELOPMENT OF A MULTI-CROP HOT-AIR SOLAR DRYER

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Appropriate technology for conversion of solar radiation to thermal energy is vital for food dehydration. Solar drying considered as an elaboration of sun drying, is an efficient system of utilizing solar energy. Reliable and low-cost multi-crop solar drying technique is required for small scale farmers in Sri Lanka. Therefore, the objective of this study was to design and develop a multi-crop hot-air solar dryer for small scale farmers. Design, fabrication, and testing were done in National Institute of Post Harvest Management, *Anuradhapura*. The main components of the equipment were flat plate solar collector, drying chamber, solar panel with air heater, turbo ventilator, exhaust fans, and temperature controller. Mild steel angle iron bars, blue iron sheets, plastic coted wire mesh, rigiform, aluminum foils, galvanized sheet, and rubber insulators were used to fabricate the prototype. Experiments were carried out to compare the open sun drying technique with multi-crop hot-air solar drying before and after installing the heater. Bitter gourd, jackfruit, and mushroom were the crops used in the experiment. The moisture removal rate of the solar dryer with heater for each crop was significantly higher than the other treatments ($p < 0.05$). The moisture removal rate for bitter gourd, jackfruit, and mushroom after installing the heater conditions were $0.151 \text{ kg h}^{-1} \pm 0.001$, $0.145 \text{ kg h}^{-1} \pm 0.004$, $0.154 \text{ kg h}^{-1} \pm 0.003$ simultaneously at 25.84% solar collector efficiency. Results indicated that the fabricated multi-crop hot air solar dryer is an effective method of conversion of solar radiation to thermal energy. Further improvements are required to increase the solar thermal efficiency of the multi-crop hot air solar dryer.

Keywords: Hot-air drying, Multi-crop, Solar drying

ANALYSIS OF TRENDS IN STREAMFLOW AND ITS LINKAGE WITH RAINFALL IN *KELANI* RIVER USING INNOVATIVE TREND ANALYSIS APPROACH

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Assessment of hydro-climatic trends is useful in resource planning especially in river basin scale under climate variability and change. This study investigated the trends of streamflow in the *Kelani* river and its association with rainfall over 30 years period. Streamflow and rainfall were assessed at six and eight stations respectively using Innovative Trend Analysis (ITA) and Mann Kendall test (MK) with Sen's slope estimator. The relationship between streamflow and average catchment rainfall was tested using Spearman's rho correlation coefficient (ρ). Both ITA and MK tests confirmed the decreasing annual and seasonal streamflow trend from mid-stream to downstream of *Kelani* river basin. A decreasing trend of rainfall was recorded in 75% and 63% stations during South West Monsoon (SWM) and Second Inter-Monsoon (SIM) respectively. However, annual, North East Monsoon (NEM) and First Inter-Monsoon rainfall showed an increasing trend in 63%, 88%, and 100% stations respectively. Moreover, there was a positive correlation between the streamflow and catchment rainfall at all time scale tested. The maximum ρ was observed for annual streamflow at *Kithulgala* gauging station ($\rho=0.61$) and the minimum ρ was recorded at *Holombuwa* station ($\rho=0.17$) with respective catchment rainfall. There was a significant association between streamflow and catchment rainfall ($p<0.05$) for the tested time period for 70% of stations suggesting that the variation of streamflow is mainly attributed to the variation of catchment rainfall. The decreasing trend of streamflow and rainfall during SWM and SIM towards the downstream area with the increasing temperature trend indicate a drying tendency of *Kelani* river basin over the study period. The results of this study are useful in formulating a sustainable plan in the usage of water in *Kelani* river basin.

Keywords: Innovative trend analysis, *Kelani* river basin, Mann - Kendall test, Rainfall, Streamflow

DEVELOPMENT OF A PORTABLE, HEIGHT ADJUSTABLE, AND SAFE SMOKER FOR CHASING GIANT HONEYBEES (*Apis dorsta*)

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Giant honeybee (*Apis dorsta*), called *Bambara* in Sinhala has been pervaded all over the Sri Lanka. It lives in a colony of a large single vertical comb, which is built in underneath of rock cliffs, branch of trees, eaves of buildings, overhead water tanks and towers at height up to 50 meters. Although they tend to be aggressive if disturbed, they are considered to be one of the most important pollinators of the nature. Tourists, pilgrims, tea pluckers and school children are often the victims of *bambara* attacks. As a solution, colony is dispelled by using various harmful methods including burning. Use of smoke toward the colony and removal of the comb is a suitable technique to dislocate them. However, a safe and reliable mechanical smoking device is not available, therefore, this study aimed to introduce a portable, height adjustable, and safe smoker for chasing them in order to resettle in another place as they are very important. Smoker consists of smoke generation unit, smoke blowing unit, power supply unit, and smoke delivery unit. The volume of the smoke generation unit is 4 L and the height of the delivery unit can be adjusted up to 10 m. Straw and Guinea grass (1:1 ratio) were used as the firing material and performance of the smoker was tested with different compaction levels using five colonies. Firing time, air flow rate, and temperature of smoke were measured during each trial. Data were analysed by ANOVA using complete randomized design at ($p < 0.05$). The suitable compaction level for the smoke generation unit was when it filled with 270 g of mixture. The firing time, smoke flow rate and the temperature of smoke at this level were recorded as 21 minutes, 18.5 Lmin⁻¹ and 37 °C respectively and it took only 8 minutes to clear the bees for easy removal of the comb. According to the performances the newly developed smoker could be recommended for chasing *bambara* bees colonies effectively and safely.

Keywords: Bambara bee, Giant honey bee, Smoker

DESIGN, DEVELOPMENT AND EVALUATION OF ANIMAL FEED BLOCK MAKING MACHINE

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The dairy industry is one of the most important industries in Sri Lanka. The present status of the dairy industry in Sri Lanka is far below expectations due to low productivity of dairy animals. Insufficient feedstuff due to the seasonal production variation is the major reason for low productivity. During dry periods, farmers can use agricultural by-products as a supplement which can be preserved as a feed block in order to supply feeds continuously. Unavailability of an affordable mechanical solution is a constraint to produce feed blocks for small scale farmers. Therefore, in this study, it was aimed to introduce an efficient and affordable feed block making machine for small scale level. The main components of the machine are hydraulically operated mold, movable piston and frame. The height, width and length of the machine were 150cm, 53cm, and 55cm respectively. The total material cost of the machine was about 35,000LKR. The evaluation of the developed machine and the produced feed blocks was done in terms of durability, post compression expansion, the time taken to optimum compaction, and the shelf life. Two mixtures of ingredients with paddy straw were used for the testing of feed blocks. The suitable compaction time for the mixture with 10% molasses and for the mixture with 5% molasses and 5% cement were 15 minutes and 10 minutes respectively at 4687 KN/m² pressure. The post compression expansion for mixtures were 18.64% and 23.73% respectively. The average weight of a block was 100 g and the volume of the block can be further increased by modifications. Any change in appearance, color, and odor of the feed blocks were not observed within 10 days of storage. According to the results it can be concluded that the machine is affordable and suitable to preserve the feedstuff as blocks.

Keywords: Durability, Feed block, Post compression expansion

VARIATION OF WATER QUALITY OF FOUR WATERSHED OUTLETS IN UPSTREAM OF MAHAWALI RIVER DURING MAHA CROPPING SEASON

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Agricultural land based water pollution has been identified as a main cause for environmental problems in Sri Lanka. Four micro watersheds, *Naranhinna*, *Kappeti-Ela*, *Rajamale*, and *Lagumdeniya* located in the *Kandy* district have been identified by the project on Rehabilitation of degraded agricultural lands in the Central Highlands implemented by Food and Agriculture Organization to rehabilitate through watershed management plan. Present study evaluated the baseline water quality status of these micro watersheds by taking water samples at the outlet of each watersheds during the *Maha* cropping seasons 2018/2019. Water samples were collected six times and analyzed for pH, EC, TDS, HCO_3^- , CO_3^{2-} , NO_3^- , NH_4^+ , available P, total K, Na, Ca, Mg, Fe, Al, As, Cd, Hg, Cr, Mn, and Pb using standard methods. Most of the tested drinking water quality parameters in all four micro watersheds were within the permissible limits of WHO standard except Fe, and NH_4^+ . Observed Fe content exceeded the WHO limits (0.3 mg/L) of all watersheds and was in the range of 1.2 – 1.5 mg/L. Concentration of NH_4^+ at *Kappeti Ela*, *Rajamale*, and *Lagumdeniya* was in the range of 0.5 to 0.7 mg/L which exceeded the WHO standard (0.5 mg/L). This study calculated Drinking Water Quality Index (DWQI) and also Irrigation Water Quality Index (IWQI) for all investigated micro watersheds using the tested parameters. The water of all four micro watersheds can be graded as excellent in terms of DWQI and it varied from 14.7 to 31.03. Considering mean IWQI (35.2 – 52.6) of tested watersheds, the water can be characterized as good for any crops during the study period. However, it is suggested to monitor the water quality status of these four micro watersheds during low rainy *Yala* cropping season to further understand entire behavior of these four micro watersheds in relation to water quality.

Keywords: Drinking water quality index, Irrigation water quality index, Micro-watershed, Water quality

APPLICATION OF REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE) MODEL TO ASSESS SOIL EROSION IN 'KALU GANGA' RIVER BASIN

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Soil erosion is one of the main forms of land degradation. Erosion contributes to loss of agricultural land productivity, ecological, and esthetic values of land and it impairs the production of safe drinking water and hydro energy production. Assessment of soil erosion is vital to identify the lands more prone to erosion. Revised Universal Soil Loss Equation (RUSLE) model supported by a geographical information system was used to assess the spatial variability of erosion occurring at *Kalu Ganga* river basin in Sri Lanka. This study used Digital Elevation Model (30 x 30 m), twenty years rainfall data measured at 11 rain gauge stations across the basin; land use and soil maps; and published literature as inputs to the model. The average annual soil loss in *Kalu Ganga* river basin varied from 0 to 134 t ha⁻¹ year⁻¹ and mean annual soil loss was estimated at 0.63 t ha⁻¹ year⁻¹. Based on erosion estimates, the basin landscape was divided into three different erosion severity classes; low, moderate and high. About 1.68% of the areas (4713.92 ha) in the river basin were identified with moderate to high erosion severity (>5 t ha⁻¹ year⁻¹) class which urgently need measures to control soil erosion. Lands with moderate to high soil erosion classes were mostly found in *Bulathsinghala*, *Kuruwita* and *Rathnapura* divisional secretarial divisions. Use of the erosion severity information coupled with basin wide individual RUSLE parameters can help to design land use management practices appropriate and improved management based on the observations, to minimize soil erosion in the basin.

Keywords: *Kalu Ganga* river basin, Revised Universal Soil Loss Equation, Soil erosion, Soil erosion hazard map

TREATMENT OF REVERSE OSMOSIS CONCENTRATE AND KITCHEN WASTEWATER BY PHYTOREMEDIATION TECHNIQUES

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Reverse Osmosis (RO) plants have been widely used in CKDu (Chronic Kidney Disease of unknown etiology) affected areas of the North Western Province as an effective drinking water treatment method. Wastewater released from RO plants concentrated with various contaminants presented in raw water is normally released to the environment without treatment. Constructed wetlands (CW) are low cost and effective technique in wastewater treatment. However, the use of CW in RO concentrate treatment is not much effective due to the availability of lower nutrient contents. Therefore, this study aimed to identify the potential of phytoremediation techniques to enhance the removal efficiency of pollutants in RO concentrate combined with kitchen wastewater. Four plant species; Vetiver (*Vertiveria zizaniodes*), Cattail (*Typha augustifolia*), Cannas (*Canna indica*) and Bulrush (*Scirpus maritimus L.*) were planted in plastic containers and soil without amendments was served as the control. RO concentrate from RO plant of the Faculty of Agriculture and synthesized domestic wastewater were fed in to the experimental pots for two months period at the rate of 0.6 Lh^{-1} . The hydraulic retention time was 42 hours. Water samples were collected from the inlets and outlets of each experiment unit by two week intervals and analyzed for pH, Electrical Conductivity, Total Dissolved Solids, concentration of Na^+ , Ca^{2+} , Mg^{2+} , $\text{PO}_4^{3-}\text{-P}$, $\text{NH}_4^+\text{-N}$, $\text{NO}_3^-\text{-N}$, Pb, As and Cd. The experiment was conducted in a Completely Randomized Design with three replicates. Removal efficiencies (RE) of all pollutants increased with time and Cannas and Bulrush plants showed higher pollutant removal. Cannas and Bulrush plants reported REs of 73%, 73%, 47% and 71%, 71%, 38% for $\text{PO}_4^{3-}\text{-P}$, $\text{NO}_3^-\text{-N}$ and $\text{NH}_4^+\text{-N}$ respectively. Therefore it can be concluded that the pollutants in RO concentrate and kitchen wastewater can be efficiently removed by phytoremediation techniques. However further studies are required to identify the most effective plant species.

Keywords: Constructed wetlands, Phytoremediation, Removal efficiencies, RO concentrate

**IMPACT OF DETERGENTS ON CHEMICAL, BIOLOGICAL AND
PHYSICAL PROPERTIES OF ALFISOL IN ANURADAPURA,
SRI LANKA**

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Disposal of untreated laundry greywater into natural environment is a common practice in developing countries. Laundry greywater contains significant amount of detergents that can alter the soil properties. The objective of this study was to evaluate the characteristics of laundry grey water and evaluate its impacts on soil physical, chemical and biological parameters. Fifteen soil samples were collected from laundry grey water disposal sites of selected households in *Puliyankulama, Anuradapura*. Simultaneously, a reference soil sample was obtained from nearby locations of each sampling point which is not influenced by grey water. Soil samples were taken from 0-30 cm and 30-60 cm depths. Similarly, undisturbed soil core samples were collected from 0-30 cm depth. Grey water samples collected from each household were analyzed for TDS, pH, EC, NO_3^- -N, PO_4^{3-} -P, Heavy Metals (As, Pb, Cd) and cations (Na, Mg, Ca, and K). Soil samples were analyzed for pH, EC, total N, PO_4^{3-} -P, Cd, As, Pb, Cation Exchange Capacity (CEC), Exchangeable Na, Mg, Ca, K, bulk density, biomass carbon and CO_2 evolution. Soil chemical, physical and biological properties of greywater contaminated sites and corresponding reference samples were compared by paired t test. Results indicate that, significantly ($p < 0.05$) lower biomass carbon and CO_2 evolution were observed in top soil samples contaminated with laundry greywater compared to reference samples and significantly ($p < 0.05$) higher pH, EC, Na, total N and available P were observed both in top and sub soil samples compared to reference samples. Moreover, CEC and Mg of topsoil in the samples were significantly ($p < 0.05$) higher compared to reference samples. However, there were no significant ($p > 0.05$) difference in bulk density, Mg in subsoil, K, Ca and heavy metals in top soil. This concludes that impact of detergents on soil chemical and biological parameters are significant compared to the physical parameters.

Keywords: Detergents, Laundry grey water, Soil parameters

ASSESSMENT OF METEOROLOGICAL DROUGHT OVER SRI LANKA USING STANDARDIZED PRECIPITATION INDEX

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Drought is one of the natural hazards which can cause huge damage to economic and social activities of human and ecosystem and is aggravated by climate change. Usually, meteorological drought precedes the other types of drought. Drought indices are vital elements for monitoring and assessment of drought and Standardized Precipitation Index (SPI) is the widely applied index to analyze meteorological drought for different time scales. In this study, drought events in Sri Lanka were assessed using SPI at 3, 6, and 12 months time scales using monthly rainfall during 1970-2017. The frequency of drought events was evaluated using SPI and trend of SPI was also detected by using the Innovative Trend Analysis (ITA) technique. The result based on SPI at annual time scale identified that hydrological years 1975-76, 1982-83, 1986-87, 1988-89, 2000-01, 2001-02, 2013-14, and 2016-17 as drought years for 52, 32, 35, 33, 33, 31, 31, and 31% of tested stations (54) respectively. The comparison of the SPI time scales discovered that more drought events ($SPI \leq -1$) occurred in April-September time scale (*Yala* cropping season) than the 3, 6 (*Maha* cropping season), and 12 months time scales. Considering in Thiessen polygon average rainfall, more frequent drought events occurred in the dry zone (57%) than the wet (49%) and intermediate zone (47%) at the annual time scale. ITA results revealed that mild ($0 > SPI > -0.99$) and heavier drought ($SPI \leq -1.5$) events are in increasing trend at 80% and 56% stations in dry zone respectively while mild drought events are in increasing trend at 57% of stations in the intermediate zone. The results indicated that the dry zone in Sri Lanka was subjected more to drought and is having an increasing tendency further in the future. The study suggests an immediate drought mitigation plan for drought prone areas, especially for the *Yala* cropping seasons.

Keywords: Drought, Drought indices, Innovative trend analysis,
Meteorological drought, Standardized precipitation index

DESIGN, FABRICATION AND PERFORMANCE EVALUATION OF A PULL TYPE SINGLE ROW MAIZE SEEDER

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Maize (*Zea mays*) is the second most widely grown cereal crop in Sri Lanka and high labor cost in cultivation is major problem in reducing the farmer profit. Most of the farmers reluctant to use available mechanical seeders due to high initial cost and some operating drawbacks of them. Therefore, this study intended to introduce a user friendly and affordable maize seeder with a high field capacity and efficiency. It has several components such as seed hopper, seed metering mechanism, seed tube, furrow opener, furrow closer, ground wheels, power transmission system and handle. The material cost for the production was only LKR4500 making it affordable for small scale farmers. The total weight was 5.65Kg facilitating the operation by a single operator. The actual and theoretical field capacities, efficiency, number of seeds per hill, planting depth and spacing of the seeder were tested for both completely prepared fields (with primary and secondary tillage) and incompletely prepared fields (only with secondary tillage) using male and female labors, separately with three replicates. The suitable forward speed for better operation was 0.164 ms^{-1} . Average number of seeds per hill and average planting depth were 2 and 3.7 cm, respectively. The within row spacing is properly maintained by machine itself. The results manifested that, the actual field capacities for female and male labors at completely prepared fields were 0.0327 hah^{-1} at 90% efficiency and 0.0329 hah^{-1} at 91% efficiency respectively. Corresponding values in incompletely prepared fields were 0.0321 hah^{-1} at 89% efficiency and 0.0323 hah^{-1} at 90% efficiency, respectively. Data were analyzed using ANOVA with 95% confidence intervals. The results showed that, type of land preparation and gender of labor have no effect ($p>0.05$) on the efficiency of the machine. Due to the affordability, user friendliness, higher capacity and efficiency, the machine can be recommended for maize cultivation.

Keywords: Field capacity, Field efficiency, Single raw maize seeder



Environmental Soil Management

COMPARISON OF SOIL CHARACTERISTICS UNDER DIFFERENT INPUT RICE PRODUCTION SYSTEMS: THE FIRST YEAR IN TRANSITION

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Rice (*Oryza sativa*) is one of the main agricultural crops in Sri Lanka. At present, rice farming in Sri Lanka is highly based on external inputs such as fertilizer and pesticides. However, many studies have revealed that long term use of chemical inputs creates adverse impacts on soil health. Hence, this study was conducted to compare soil characteristics of rice fields under organic, conventional and reduced input use production systems. The experiment was carried out in the research field, Faculty of Agriculture, Rajarata University of Sri Lanka during *Maha* cropping 2018/2019. Soil samples were collected from three production systems just after land preparation and maximum tillering stage and were analyzed for soil properties and characteristics. Data analysis was done by mixed procedure model using the Statistical Analysis System. Total nitrogen and available phosphorous of all three systems were significantly higher ($p < 0.05$) at maximum tillering stage compared to initial levels. Significantly higher ($p < 0.05$) total and ammonium nitrogen levels were reported in conventional system at maximum tillering stage compared to other systems. However, highest soil microbial activity at the maximum tillering stage was reported in organic system. Organic and reduced systems showed significantly higher ($p < 0.05$) available P content at the maximum tillering when compared to initial levels. This may probably be due to microbial mineralization of soil P. Exchangeable Potassium, Cd, As and Pb were not significantly different ($p > 0.05$) among three input systems. Results revealed that organic and reduced input systems showed better microbial activity than conventional system. However, long term investigations are needed to confirm other findings.

Keywords: High external input, Organic farming, Reduced input use system, Rice cultivation, Soil characteristics

**NUTRIENT LEVELS AND TRACE ELEMENTS IN RICE PLANT
UNDER DIFFERENT INPUT MANAGEMENT SYSTEMS: THE FIRST
YEAR IN TRANSITION**

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Rice plant nutrients uptake behaviour is very important in site-specific nutrient management (SSNM) to determine timing and doses of different nutrients. This study was conducted to investigate the impact of different inputs management systems (IMS) on bioaccumulation of nutrients and trace elements at different growth stages of rice plant. Leaf samples were collected at seedling, panicle initiation and 50% flowering stages from conventional (Department of Agriculture recommendation), reduced (50% Department of Agriculture recommendation and 50% organic manure) and organic manure applied plots. Leaf total Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg) and trace elements (Mn, Cu, Fe, Zn, As, Cd and Pb) were determined using standard analytical procedures. Data were statistically compared by mixed procedure and mean separation was done by Tukey's HSD test using SAS. Results revealed that, N, P, Ca, Mg, Cu, Mn, Pb and As of leaf tissues were significantly differed ($p < 0.05$) across three IMSs. However, K, Fe, Zn, and Cd of leaf tissues were not significantly different ($p > 0.05$) across IMSs. Leaf tissues contents of all analysed elements except Zn and P were significantly different ($p < 0.05$) across the studied time periods. Plant uptake of all analysed elements except As, Cd and Pb in all three treatments were significantly higher at the 50% flowering stage in comparison to other growth stages. Differential plant uptakes of nutrients and trace elements were observed in three IMSs at each growth stage. Dry matter of each treatment has significantly increased at seedling, panicle initiation and 50% flowering stages across growing season ($p < 0.05$) at three IMSs. Differences in uptake behaviours of rice plants in three IMSs emphasized the relevance of SSNM on the basis of IMSs.

Keywords: Input Management Systems, Paddy, Plant nutrients, Trace elements

NUTRIENT AND TRACE ELEMENT LEACHING IN PADDY SOILS UNDER DIFFERENT INPUT MANAGEMENT SYSTEMS: THE FIRST YEAR IN TRANSITION

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Detailed study of nutrient leaching provides a strong basis for the formulation of eco-friendly and economical site-specific fertilizer recommendations. Hence, this study was conducted to evaluate the leaching behaviour of nutrients and trace elements under conventional (Department of Agriculture recommendation), reduced (50% of DoA) and organic input management systems (IMs) in rice grown in Low Humic Gley (LHG) soils. Leachate samples were collected from the field plot experiment conducted at the Faculty of Agriculture, Rajarata University of Sri Lanka. Porous PVC tubes were installed in the middle of each treatment plot just below the plough layer to collect leachate. The leachate samples were analysed for nutrients and trace elements using standard methods. Data were analysed following the mixed procedure. The results showed that NO_3^- -N and Arsenic (As) in leachate were significantly different ($p < 0.05$) among different IMs. The highest and lowest amount of NO_3^- -N leaching throughout the growing season were observed in conventional and organic rice plots respectively where the values were significantly different at before sowing stage while not significantly different ($p > 0.05$) after sowing up to panicle initiation stage and 50% flowering stage. The higher As leaching was observed in conventional fields, whereas, it was comparatively lower in reduced and organic fields before sowing. Comparatively lower As leaching was observed after sowing stage, while as leaching was not detected at flowering stage in all IMs. The pH, alkalinity, NH_4^+ -N, dissolved reactive P, exchangeable K^+ , Na^+ , Ca^{2+} , Mg^{2+} , Cd, Pb and Sodium Absorption Ratio were not significantly different among different IMs, while significantly different over time. Moreover, Electrical Conductivity and Total Dissolved Solids were not significantly different among different IMs as well as different time scales of the studied period. Different nutrients leaching behaviours in LHG under different IMs emphasize the high relevance of eco-friendly and economical specific nutrient management on the basis of IMs.

Keywords: Input management system, Leachate, Low Humic Gley, Nutrients,

IMPACT OF DRINKING WATER QUALITY AND LIFESTYLE FACTORS ON CHRONIC KIDNEY DISEASE OF UNKNOWN ETIOLOGY PREVELANCE IN *MALWATHUOYA* CASCADE

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Chronic Kidney Disease of unknown etiology (CKDu) is one of emerging health problems in Sri Lanka. Though the literature has reported many causal factors, the exact root causes responsible for the disease are still unknown. However, many studies have shown that poor drinking water quality and human lifestyles have significant impacts on the prevalence of CKDu. This study attempted to verify the impacts of water quality factors and lifestyle factors on CKDu prevalence in *Malwathuoya* cascade. Water samples were collected from CKDu prevalence and non-prevalence households in *Ihalagalkulama* and *Sivalakulama* Grama Niladhari Divisions of *Galenbindunuwewa* District Secretary Division. Samples were collected from wells used during past 25 years period by CKDu prevalence and non-prevalence households in study areas. Samples were tested for several water quality parameters. Information on lifestyle factors were also collected through a questionnaire survey. The study finds that the concentrations of As and hardness are significantly higher ($p < 0.05$) in CKDu prevalence households in comparison to non-prevalence households in *Sivalakulama*. Moreover, the average value of As in *Sivalakulama* lower than the SLS (614:2013) maximum permissible values, while the hardness and alkalinity of water are greater than the SLS maximum permissible values. The study could not identify significant differences of As, Pb, Mn and Fe in CKDu prevalence households compared to CKDu non-prevalence households in *Ihalagalkulama*. Moreover, alkalinity, As, Pb and Fe in both CKDu prevalence and non-prevalence households, Mn in CKDu prevalence households and NO_3^- -N in CKDu non-prevalence households at *Ihalagalkulama* exceeded SLS set maximum permissible values. The questionnaire survey revealed that the most of CKDu patients are farmers (92%) and they expose to heavy sun during the field work. The results also revealed that higher the use of agrochemicals and exposure to agrochemicals, the greater the prevalence of CKDu in *Malwathuoya* cascade.

Keywords: CKDu, Life style factors, Water quality

TREATMENT OF BATHROOM WASTEWATER IN MICROBIALLY IMPROVED CONSTRUCTED WETLAND USING BULRUSH PLANT

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Constructed wetland (CW) systems have emerged as an alternative low cost and sustainable wastewater treatment systems. Combination of wetland plants and microbial inoculums have been identified as the most effective treatment in enhancing the pollution removal efficiency of CWs. Literature revealed that CW system with bulrush (*Scirpus californicus*) plants was performed poorly in removal of certain pollutants. Hence, this study focused to enhance the pollution removal efficiency of CW with bulrush plants by introducing a fungal inoculum. The CW system was located in the Faculty of Agriculture, Rajarata University of Sri Lanka. The fungal inoculum was added to the soil surface of the CW with already established bulrush plants. The grey water discharged from a student hostel complex was directed in to the wetland at the average rate of $0.75 \text{ m}^3 \text{ h}^{-1}$. The hydraulic retention time was 45 hrs. Water quality parameters of the influent and effluent were monitored in two week intervals for a period of four months by analysing biological oxygen demand (BOD_5), nitrate-nitrogen ($\text{NO}_3^- \text{-N}$), ammonium - nitrogen ($\text{NH}_4^+ \text{-N}$), phosphate - phosphorous ($\text{PO}_4^{3-} \text{-P}$), total dissolved solid (TDS), dissolved oxygen (DO), pH and electrical conductivity (EC). The results revealed that the system reduced the concentration of contaminants with the increasing removal efficiencies (REs) throughout the monitoring period. The average REs of BOD_5 , $\text{NO}_3^- \text{-N}$, $\text{NH}_4^+ \text{-N}$, $\text{PO}_4^{3-} \text{-P}$ were 59.6%, 40.5%, 28.7%, 72.6% respectively. The average pH (6.84) of the effluents was ranged around the neutral, TDS (237.3 mg L^{-1}) and EC (313.2 S cm^{-1}) also ranged within the permissible level following the natural standards for waste water. Overall it can be concluded that the microbially improved CW performed effectively in removal of all measured parameters, comparatively highest in removal of $\text{PO}_4^{3-} \text{-P}$. However, repeated studies would be needed for a concrete conclusion.

Keywords: Constructed wetlands, Fungal inoculum, Greywater treatment, Removal efficiency

**SOIL AND WATER QUALITY CHARACTERISTICS OF AGRO-WELLS
IN NEWLY DEVELOPED FARMLANDS IN MAHAWELI SYSTEM
L – ATHAWATUNUWEWA BLOCK**

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Agro-wells are the most reliable water resource in newly developed farmlands in Mahaweli System L. However, water quality of agro-wells and its relationship with nutrient management in surrounding farmlands have not yet investigated. This study was conducted to investigate agro-well water quality, to explore its relationship with soil nutrient management and to explore short-scale soil spatial variability of surrounding areas of agro-wells. Water samples were collected from 10 agro-wells located in the study area at three time points. Soil samples from surrounding farmlands of each agro-well were also collected from 0-15 cm depth. In addition, intensive soil sampling was done surrounding a selected well to prepare soil short-scale spatial variability maps using Inverse Distance Weighting interpolation technique. Water samples were analysed for pH, EC, TDS, Mg, Ca, Na, K, NO₃-N, NH₄-N, Available phosphorus, Available Sulphur and Cd, As, Pb. Moreover, Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were calculated of each water sample. Measured water quality parameters were compared with FAO guidelines. Soil samples were analysed for pH, EC, Available N, P, K, Mg, Ca, Na, S and total N, Cd, As, Pb. Correlation analysis was performed to investigate relationship between soil and water quality parameters of measured nutrients. All water quality parameters except NO₃-N, K and Cd were within acceptable range. K, Cd in all studied agro-wells and NO₃-N levels in 6 agro-wells have exceeded the maximum permissible level. Correlation analysis revealed a strong positive linear correlation between soil and water concentrations of NO₃-N ($r = 0.83$) Available Sulphur ($r = 0.81$) and Ca ($r = 0.82$). Natural short-scale spatial variability pattern of soil N, P, K in the studied area have been altered due to anthropogenic activities such as fertilizer applications.

Keywords: Agro-well, Soil spatial variability, Water quality

REPLACING TRIPLE SUPER PHOSPHATE FROM BIOFILM ENRICHED *EPPAWALA* ROCK PHOSPHATE IN RICE CULTIVATION

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Combined application of biofilmed biofertilizer recommended for rice (Biofilm-R) and *Eppawala* Rock Phosphate (ERP) has a greater potential to be used as an alternative to Triple Super Phosphate (TSP). Hence, this study was mainly focused to evaluate the TSP replacing potential of Biofilm-R-enriched ERP in rice cultivation, using a soil leaching tube experiment under laboratory condition. A modified chemical fertilizer (CF_M) mixture was developed by replacing TSP in the rice fertilizer recommendation (CF_E) of the Department of Agriculture (DoA) from Biofilm-R - enriched ERP. However, nitrogen (N) and potassium (K) levels were maintained according to the DoA recommendation. Six treatments were used with CF_E and CF_M at the different rates (65%, 85% and 100%) of Biofilm-R- enriched ERP. Soil alone was used as the control. The experiment was arranged in a completely randomized design with three replicates. Soil pH, available N and P, organic matter (OM) and microbial biomass C were measured before and after the experiment. In every two weeks, solubilized P was recovered by leaching for three months. Initial soil showed an optimum pH (7.27) and also had sufficient amounts of available N (77 mgkg^{-1}), available P (14.38 mgkg^{-1}) and exchangeable K (107 mgkg^{-1}) for rice plant growth. However, OM (1.14%) and microbial biomass C (2.68 mgg^{-1}) were very low. In leachates, 100% ERP coupled Biofilm-R recorded significantly ($p < 0.05$) higher solubilized P compared to other treatments. Overall, biofilms applied treatments recorded higher microbial biomass at the end. Results conclude that 100% ERP coupled with Biofilm-R in the CF_M performed better than the DOA recommended TSP dosage. Therefore, Biofilm-R enriched 100% ERP can be proposed as an alternative to TSP in rice cultivation. However, further studies are needed to evaluate the effectiveness of this Biofilm-R enriched 100% ERP under field conditions.

Keywords: Biofilms, *Eppawala* rock phosphate, Triple super phosphate

MICROBIAL BIOFILMS FOR BIOSOLUBILIZATION OF *EPPAWALA* ROCK PHOSPHATE

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Biofilms are complex multi-cellular communities of microbes, some of them have potential to biosolubilize certain nutrients in the substrate. National Institute of Fundamental Studies (NIFS) has developed four biofilm formulations (BF1, BF2, BF3 and BF4) with the potential of solubilizing phosphorus (P) in *Eppawala* Rock Phosphate (ERP) and they have shown promising results in preliminary studies. Thus, this study was designed to evaluate the efficacy of these biofilm formulations in solubilizing ERP. A laboratory tray experiment was conducted under controlled conditions in a completely randomized design with three replicates. Five treatments were tested; the four biofilm formulations were sprayed separately (1.7 L of biofilms per 100 kg of ERP) into trays with a thin uniform layer of autoclaved ERP and also a control tray without a biofilm. Data were statistically analysed using analysis of variance followed by mean separation using Tukey's HSD test. Available P, water soluble P, microbial biomass C and P, pH and other microbial observations were taken in two weeks intervals for three months. Results revealed that BF3 was significantly higher ($p < 0.05$) in releasing cumulative available P (279.9 mgkg^{-1}), water soluble P (160.7 mgkg^{-1}), biomass P (212.9 mgkg^{-1}) with the heaviest microbial biomass (2.3 mgg^{-1}) attached with ERP, compared to the other tested biofilms. All the biofilm treatments showed acidic pH throughout the experiment since they were producing organic acids when solubilizing P. The overall results conclude that the BF3 is the most efficient biofilm formulation in solubilizing ERP. Thus, further studies are recommended to evaluate the potential of using BF3 under field conditions in enhancing the solubilization of ERP.

Keywords: Biofilms, Biosolubilization of phosphorous, *Eppawala* rock phosphate

EFFECT OF DIRECT DISPOSAL OF REVERSE OSMOSIS CONCENTRATE ON SOIL CHEMICAL CHARACTERISTICS IN DISPOSAL SITES

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Reverse Osmosis (RO) is one of the most effective methods to provide safe drinking water for chronic kidney disease affected areas in the North Central Province, Sri Lanka. The rejected water or the concentrate of many RO plants is about 75% of the feed water volume. The concentrate disposed from RO plants includes all the removed through RO membrane. Direct disposal of RO concentrate into the soil may create long term environmental issues. Hence, this study was conducted to analyse the soil chemical characteristics of RO concentrate disposal sites. Ten community-based RO plants were selected to collect soil samples. Reference soil samples were also collected from non-affected locations of the same sites to compare soil characteristics. Both soil samples were analysed using standard methods for chemical characteristics. Soil analysis revealed that disposal of RO concentrate has significantly enhanced ($p < 0.05$) pH, EC, available N, P, K, Ca, Mg, Na, and Cu of the soil compared to the reference soil samples in all 10 locations. Studied four locations had remarkably higher percentages of EC, available Na, Mg and Ca (i.e: 87%, 96%, 90%, 80% respectively) than the reference soil. However, Cd, As and Pb accumulation in concentrate disposal sites was not significantly different ($p > 0.05$) compared to reference samples. Water quality analysis showed significantly higher ($p < 0.05$) levels of EC, TDS, NO_3^- , PO_4^{3-} , Pb, Na, K, Ca, Cl, F and Mg contents in the concentrate compared to feed water in all the tested RO plants. However, no significant difference was reported in Cd, As, and Zn between feed water and the concentrate. Hence, there is a potential to build up salinity and sodicity in RO concentrate disposal sites and deteriorate soil health in the long term. However, this study should be continued to confirm long term effects.

Keywords: Concentrate, Direct disposal, Reverse osmosis, Soil characteristics, Water quality



Agricultural Economics and Extension



**DETERMINANTS OF HOUSEHOLD FOOD SECURITY IN
ANURADHAPURA DISTRICT, SRI LANKA**

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There are lack of studies undertaken to examine the food security status at the household level in the dry zone of Sri Lanka, where food insecurity is relatively strive. The purpose of this study was to assess the determinants of the food security of Anuradhapura district of dry zone. Data on Household Income and Expenditure Survey, 2016 conducted by Department of Census and Statistics were used with a sample of 793 households. Descriptive statistics, Food Security Index (FSI) and the logistic regression model were applied for the data analysis. The FSI was calculated using the ratio of the recommended daily per capita calorie requirements to the daily per capita calorie intake of the household to capture the access dimension of the food security. Results revealed that 42% of the households were food insecure in the study area with inadequate daily calorie requirement. The log likelihood value of the model was -463.234 ($p < 0.05$) showing that the variables included in the model were major determinants of the food security. Accordingly, gender, age, marital status of the household head, monthly total income, indebtedness and the size of the household were significant in determining the food security of the area. Male headed households ($p < 0.05$), and monthly household income ($p < 0.1$) were positively related with the food security and household size ($p < 0.05$), age of the household head ($p < 0.05$), single parent households ($p < 0.1$) and indebtedness ($p < 0.1$) were negatively related with the household food security. The study concluded high incidence of food insecurity at household level in *Anuradhapura* district. Special attention should be placed on female headed households, large households, single parent households and households with older aged heads in formulating food security policies in order to ensure household food security of *Anuradhapura* district.

Keywords: Determinants, Food Security, Food Security Index,
Logistics regression

EFFECTS OF GLYPHOSATE BANNING AND ADAPTIONS OF MAIZE FARMERS IN DRY ZONE, SRI LANKA

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Maize is an important course grain grown in the dry zone of Sri Lanka. Glyphosate was the most popular and effective weed killer used in maize cultivation until it was banned in 2015. People argue that banning of glyphosate negatively affect the maize cultivation because no substitute was introduced for maize as a weed killer. Hence, the objectives of this study were to identify the effects of glyphosate banning and adaptions methods used by maize farmers. A field survey was conducted using purposively selected 60 farmers from *Kahatagasdigiliya*, *Horowpathana* and *Galenbindunuwewa* Agricultural Instructor (AI) divisions in *Anuradhapura* district. Time series data from 2000 to 2017 on maize production, cultivation extent, cost of production (COP) and monthly rainfall were collected from Hector Kobbekaduwa Agrarian Research and Training Institute, Provincial Agricultural Department of North Central Province and Department of Meteorology. The effect of glyphosate banning on cultivation extent, maize production and cost of production were analyzed by fitting general linear models. The categorical variable, adequacy of rainfall was used to remove the effect of rainfall. The results revealed that banning of glyphosate has not significantly affected the cultivation extent and yield ($p > 0.05$), while it significantly affected the COP ($p < 0.05$). The average COP per acre has increased from Rs. 47,701 to Rs. 57,254 with banning of glyphosate. About 39% of respondents use herbicides and 28% of respondents use Monosodium glutamate, while 23% of respondents use kerosene oil with other chemicals as alternatives for glyphosate. The study concludes that banning of glyphosate has significantly increased the COP, hence the cost-effective alternative weed control methods should be introduced for the sustainability of maize cultivation.

Keywords: Adaption measures, Cost of Production, Glyphosate, Maize

PRICE AND INCOME ELASTICITIES OF DEMAND FOR SELECTED VEGETABLES IN SRI LANKA

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Vegetables play an important role in Sri Lankan diet; hence it provides micro nutrient for a healthier life. Thus, it may reduce the risk of non-communicable diseases and cancers. However, in today's context, the daily intake of vegetable is far less than the recommended amount by WHO. Hence this study investigates the price and income elasticities and the effect of demographic factors for the consumption of selected low country vegetable in Sri Lanka by utilizing the secondary data of Household Income and Expenditure Survey (HIES) 2016, of Department of Census and Statistics. The sample size was 21,756 housing units representing the all three sectors (Urban, Rural, Estate) in Sri Lanka. Data were collected by 12 months survey. The data were analyzed by using double log demand function. The own price has negatively significant for all vegetables and positively significant for income at ($p < 0.05$). Own price elasticity and income elasticity were, Okra (-0.48, 0.01), Bitter gourd (-0.37, 0.02), Long bean (-0.53, 0.04), Snake gourd (-0.40, 0.01), Ridge gourd (-0.47, 0.04), Pumpkin (-0.50, 0.03), Tomato (-0.54, 0.02), Wing bean (-0.36, 0.01), Drumstick (-0.39, 0.03), *Kekiri* (-0.52, 0.02), Eggplant (-0.42, 0.03), *Thibbatu* (-0.43, 0.03). Among the demographic factors, education was negatively significant ($p \leq 0.05$) for all selected vegetables except Wing bean, Eggplant and *Thibbatu*. Age of the household head and family size were not significant. However sector wise has a minor impact on consumption of vegetables. This inelastic price demand conclude that vegetables have limited substitutes and as a result choice remain the same. Based on results high vegetable prices adversely affect for the consumption. Therefore affordable vegetables prices are important to promote the consumption. Income has shown a positive impact on vegetable consumption. Further, due to the positive impact of income and hence the market opportunity producers are recommended to cultivate low country vegetables.

Keywords: Double log demand function, Income elasticity, Low country Vegetables, Price elasticity

EXCHANGE RATE ON TRADING OF COIR PRODUCTS OF SRI LANKA

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Coconut is an export-oriented industry, which secured Rs 94,773 million export earnings in 2018. Among many versatile coconut-based products exported, coir fiber and coir fiber finished products contribute significantly for foreign exchange earnings and it was as high as 32% in the last year. Even though, this contribution is substantial, Sri Lanka has lost its place as the world largest coir fiber exporter in the international market. To be competitive in the global coir trade, where new producers are emerging, identification of factors affecting coir trade is imperative. This study applied Gravity model of trade to estimate empirically the factors affecting exports of coir fiber and coir fiber finished products with special reference to the impact of exchange rate. In the model, the quantity of coir exports was used as the dependent variable. The independent variables included in the model consists of traditional gravity variables, i.e. Gross Domestic Product, population, geographical distance, and country specific variables such as exchange rate, presence of regional trading agreements, colonial relationships, and common language. Data extracted from Sri Lanka and its major exporting destinations accounting for 10 countries in total, for the period 2008-2017 were used for the analysis. The results of the Gravity model estimation showed that coefficients of common gravity variables bear expected signs and statistically significant. Results indicate that exchange rate is not a significant determinant of coir fiber exports of Sri Lanka. One of the reasons behind this phenomenon may be the perennial nature of the coconut where changes in supply response is not possible in the short-run.

Keywords: Exchange rate, Coir products, Gravity model, Exports

PRICE BEHAVIOUR OF VEGETABLES AT DAMBULLA DEDICATED ECONOMIC CENTRE: AN ECONOMETRIC ANALYSIS

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Vegetable is the second most important agricultural commodity next to rice. Price fluctuation is one of the major problems faced by the vegetable farmers around the country. This study aimed to identify the price behavior of major vegetables in *Dambulla* Dedicated Economic Centre which is the main trade centre for vegetables in Sri Lanka. Data of monthly nominal prices of vegetables from January 1996 to November 2018 were obtained from Hector Kobbekaduwa Agrarian Research and Training Institute. Based on the coefficient of variation, five highly price fluctuated vegetables were selected namely Snake gourd, Brinjal, Pumpkin, Tomato, and Cucumber. The nominal prices were converted to real prices using Colombo Consumer Price Index. According to analysis of trend, real prices of the vegetables have been increasing over time. The increased percentage of real price values for Snake gourd, Brinjal, Pumpkin, Tomato and Cucumber were 6.54%, 7.28%, 4.6%, 8.44%, and 3.54% respectively. Increased real prices over the years reveal that vegetable prices have increased above the inflation rate leading to inadequate supply to meet the annual demand. The prices obtained from the seasonal analysis were high during November-January and April-June. The highest price increase compared to the lowest values was reported for Snake gourd (122%) followed by tomato (106%). According to this study it reveals that the real prices of vegetables increase with the time and also there is a huge prices fluctuation within the year. In order to minimize the effects of high price fluctuation, it is recommended to make farmers aware of seasonal price variation so that farmers having water supply can cultivate vegetables during the off season. Market-led production planning should also be implemented. Increased vegetable supply is necessary to control the real prices to make prices affordable to the consumer.

Keywords: Price fluctuation, Price trend, Real price, Seasonal analysis, Vegetables



Agricultural Systems and Management



**CONTRIBUTION OF TRADITIONAL STRATEGIES TO ENHANCE
THE FOOD AND NUTRITION SECURITY IN *PALUGASWEWA*
CASCADE SYSTEM, SRI LANKA**

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Use of traditional knowledge in food production has started to die off in Sri Lanka at present. In the meantime, adverse impacts of climate change have resulted significant losses in the food production. However, the ancient dry zone cascade system produced enough food utilizing traditional knowledge. This research was carried out with four objectives to support the food security in the dry zone, accordingly, to determine the adoption levels of traditional knowledge in food production, to identify the constraints related to the use of local farming practices, to identify the women's role in ensuring the food security at present and to evaluate factors affecting household food security. A sample of 120 farmers was randomly selected from *Palugaswewa* cascade system in *Anuradhapura* district. A pre-tested questionnaire and four key personal interviews were administered for data collection. Results revealed that 52% of the respondents use traditional practices for food production, processing, storing and preservation. Meantime, 48% of respondents do not use traditional practices due to less popularity (33%), limited access to the traditional seeds and equipment (29%) and limited knowledge (21%). Further, 58% of female respondents engaged in agricultural activities on average ($1-5 \pm 1.34$ hours per day). In this regard all most all female respondents spend at least one hour for activities such as food processing (65%), keeping food stocks (40%) and searching foods (59%). Generalized linear model results revealed that, food security score of households is impacted by age, marital status, household size, household income, land area, home gardening and traditional knowledge use at ($p \leq 0.05$). Based on the results, the strategies based on traditional knowledge play a vital role in food security enhancement in *Palugaswewa* cascade system, Sri Lanka insisting that traditional knowledge still should be promoted.

Keywords: Food production, Food security, Traditional knowledge

AGROTOURISM AS AN ADAPTATION STRATEGY FOR CLIMATE CHANGE IMPACTS IN TEA PLANTATIONS OF SRI LANKA

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The production of the Ceylon tea has been experiencing frequent negative fluctuations in the recent past. The phenomenon of climate change is one of the major reasons for the declined productivity and hence the income. Therefore, the tea plantation sector of Sri Lanka should concern more on income diversification methods as supplementary income sources. A blend between the tea and tourism industries has been identified as a possible solution in this regard. The study assesses the feasibility of tea tourism as an adaptation strategy for climate-induced income losses in the tea plantations in Sri Lanka. The study used a sample of 56 estates, selected through snowball sampling method. The required data were collected through a questionnaire survey together with key informant discussions and site observations. Primary data on general information, production details and the information on tea tours of the tea estates were collected during the survey. The collected data were analyzed using descriptive methods and Probit regression. The results of the regression analysis revealed that the estates with low land productivity, high labor productivity and small in scale of operation are more likely to adopt tea tourism as an income diversification method ($r^2 = 87\%$, $p < 0.05$). Almost every respondent believed that they experience loss of productivity even with a slight change of climate. As much as 83% of estates perceive the climate-induced fluctuations in tea revenue as a motivating factor for practicing of tea tourism. The study identifies the lack of government support as a major barrier in disseminating the tea tourism concept in the tea plantation sector of Sri Lanka. Further, the study finds that even at a very basic level, the concept of tea tourism contributes approximately two percent to the total income of the estate suggesting the potential to offset the climate-induced income losses in the plantation sector of Sri Lanka.

Keywords: Income, Productivity, Tea plantation, Tea tourism

**WILLINGNESS TO ADOPT GOOD AGRICULTURAL PRACTICES
(GAPs) BY VEGETABLE FARMERS IN ANURADHAPURA DISTRICT,
SRI LANKA**

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Vegetables are an essential component in food production and consumption. Farmers tend to obtain a higher yield by adopting improper agricultural practices which are not recommended by the Department of Agriculture, Sri Lanka, leading to high cost of production and many health issues. Good Agricultural Practices (GAPs) have been introduced to vegetable farmers to mitigate the adverse effect of improper agricultural practices and increase profit. This study aimed to identify the level of adoption and the factors affecting the use of GAPs by the vegetable farmers in *Anuradhapura* district. A sample of 120 vegetable farmers from four DS divisions: *Thambuththegama, Galenbindunuwea, Rambewa, Medawachchiya* were selected using two stage purposive sampling technique. Semi-structured pre-tested questionnaire was used to collect information on demographic, production and cultivation factors. Level of adoption (LADOPT) of GAPs was calculated based on the numbers of GAPs adapted by farmers. Farmers were categorized as good, moderate and poor level of GAPs practitioners based on the LADOPT scores. Data were summarized using descriptive methods and multiple linear regression model was used to identify the relationship between LADOPT scores and other variables. Results showed that 28%, 40% and 32% of respondents practice good, moderate and poor LADOPT respectively. Good adopters have a higher income compared to the moderate and poor level of adopters. Sixty percent of vegetable farmers were willing to practice GAPs if they receive required the knowledge and information. Results further revealed that adoption of GAPs was significantly related with education level ($p=0.0489$), farming experience ($p=0.0340$), awareness on GAPs ($p<0.0001$), unit cost ($p=0.0096$) and unit income ($p=0.0086$). Awareness is a crucial factor for adopting GAPs by vegetable farmers. Appropriate training, extension and awareness programs are needed for popularizing the GAPs among vegetable farmers in *Anuradhapura* district, Sri Lanka.

Keywords: Adoption level, Good agricultural practices, LADOPT scores, Vegetable farmers

IMPACT OF DROUGHT ON FOOD SECURITY IN ANURADHAPURA DISTRICT, SRI LANKA

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Sri Lanka, a country in the tropical region has experienced cyclical droughts of high intensity, occurring in the intervals of three to four years. These droughts have had a series of adverse impacts on the household food security especially in areas with rain-fed cultivation. This study assessed the impacts of drought on food security by comparing normal and drought situations in minor irrigation areas and ascertained mitigation strategies adapted by households of the *Anuradhapura* district. The survey conducted by the Department of Environmental Management of the Faculty of Social Sciences and Humanities of Rajarata University of Sri Lanka in 2017 was used for the study. Data collected from 533 randomly selected households from eight divisional areas in minor irrigation schemes in *Anuradhapura* district were analyzed employing descriptive statistics and paired T-test using SPSS software. The results reveal that paddy productivity has reduced during the period of droughts by 49% compared to the normal season. The mean comparison between two periods found that drought has a significant negative impact on paddy productivity ($p < 0.05$) creating food insecurity of the households in the study area. Further, during the drought period majority households received insufficient incomes to meet the daily necessities and hence savings were utilized for essential household needs such as food (64%), children's education (28%), and health (21%). The major drought coping strategies used by households include consuming less amount of favorite foods (49%), borrowing foods (56%), reducing quantity of meals (27%), skipping meals (2%), reducing buffer stock of seeds (28%), use of food reserves (40%), collecting rainwater (76%), and food preservation (20%). Introduction of drought resistant paddy varieties, provision of credit facilities, renovation and reconstruction of village tanks, and popularizing of drought coping strategies among paddy farmers are needed to mitigate the impacts of droughts on household food security.

Keywords: Drought, Household food security, Paddy productivity

**FACTORS AFFECTING LOW ADAPTATION OF ORGANIC
VEGETABLE FARMING: A CASE STUDY OF KURUNEGALA
DISTRICT**

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Although organic farming is associated with ecologically and economically sustainable form of agriculture, its adaptation is extremely low in Sri Lanka. Therefore, this study was conducted to examine factors affecting organic vegetable farming in *Kurunegala* district. A total of 100 farmers representing 50 each in organic and nonorganic were interviewed using a pretested questionnaire. Demographic analysis, binary logistic regression, and Likert scales were used to analyze the data. Demographic analysis showed that the family labor has a strong relationship with the adaptation of organic farming and women are more involved in organic farming (46%) than nonorganic farming (24%). Further, organic farmers are more educated having O/L or above (56%) than conventional farmers (46%). The likelihood ratio statistic of 40.61 is statistically significant ($p < 0.01$) showing that identified ten variables in logic model are major determinants of adaptation of organic farming. Number of family labor ($p = 0.001$), high demand for organic product ($p = 0.012$) and age of the farmers ($p = 0.002$) have positive impact while low yield of organic farming ($p = 0.019$) and farmer experiences in agriculture ($p = 0.001$) have negative impact on adaptation of organic farming. Income and cost of production have no significant impact on adaptation of organic versus inorganic vegetable farming. Nevertheless, a higher productivity of nonorganic farming was reported compared to the organic farming. Likert scale analysis showed that the majority of organic farmers have limited constraints compared to the nonorganic farmers. The problems of supplying of fertilizers, controlling pest and diseases and producing large quantities of organic products were faced by organic farmers at present. In conclusion, low adaptation of organic farming is mainly due to farmers' perception of low yield of organic farming, and lack of financial support to produce organic vegetables. Major recommendations for prompting organic farming are organizing farmer training and provision of credits.

Keywords: Nonorganic, Organic, Sustainable, Vegetable

DETERMINANTS FOR CONVERTING CONVENTIONAL TEA TO ORGANIC TEA FARMING IN *NELUWA SINHARAJA* BUFFER ZONE, SRI LANKA

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Promoting organic tea farming is getting popularized as conventional intensive tea farming which is also leading to emerging environmental and social problems. This study aimed to explore the determinants of farmers' conversion decision from conventional tea to organic tea in *Neluwa Sinharaja* buffer zone in Sri Lanka. A questionnaire survey of 200 organic and inorganic tea farmers was done in data collection. Descriptive analysis, Mann-Whitney test and logistic regression were employed in data analysis. Majority of farmers in both farming systems were male and within 41-50 age group. Moreover, farm gate prices of organic tea varied between Rs. 90-117 kg⁻¹, while conventional tea prices varied between Rs. 70-93 kg⁻¹. Organic tea farming reported better economic performances: high product price, maximum utilization of on-farm/community resources and low cost of production as well as better environmental performances like discharging non-polluted water, enhancing soil fertility and soil erosion compared to conventional tea farming. Logistic regression revealed that, farming experiences (OR=0.218), training participation (OR=4.348), access to extension services (OR=7.509), size of households (1.963), farm gate price (OR=1.829), yield (OR= -0.003) and total cost (OR=1.000) as determinants significantly ($p<0.05$) affecting on conversion decision from conventional tea to organic tea farming while land extent (OR=0.096) was significantly affecting determinant at 10% significance level in *Neluwa Sinharaja* buffer zone. The study recommends to focus on aforesaid significant determinants when motivating farmers to convert from conventional tea farming to organic tea farming in other potential areas in the country.

Keywords: Conventional, Determinants, Organic, Performance, Tea farming

PRESENT STATUS OF AGRICULTURE EXTENSION AND ADVISORY SERVICES PROVISION FOR FOOD CROPS IN ANURADHAPURA DISTRICT, SRI LANKA

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The role of extension and advisory services is imperative for agricultural development. Recently, the performance of the extension sector in Sri Lanka, especially the state sector at key agricultural locations has been questionable. Thus, this study aimed to explore the status of agricultural extension service for the food crop sector at the *Anuradhapura* District. Multistage sampling technique was employed to draw a sample of 120 farmers representing major food crop categories. Descriptive analytical techniques, factor analysis, constraint analysis and Poisson regression were used for data analysis. Accordingly, compared to state sector (92%) private institutes offer extension services for selected farmers (47%), whilst the participatory approach is exercised by NGOs (16%). Though, majority of the teaching methods and information types offered by the state sector perceived to be ineffective, method demonstrations (77%), farm and office visits (68%) as teaching methods and varietal selection (59%), pest and disease management (62%) as information types were perceived to be comparatively effective. Farmer expectations on extension improvements were extracted from Factor analysis in to supplementary services (66% variation), qualities of extension agent (17%) and value of extension information (8%). According to constraint analysis, insufficient market-driven extension (19%) and lesser extension contacts at the field level (17%) and shortage of field staff (20%) and inadequate support services (17%) were the major constraints faced by farmers and extension agents respectively. The Poisson regression analysis revealed that the farmer's age, being an executive committee member of farmer organization and distance to extension office significantly affect the number of effective extension contacts. Compared to old - aged farmers (>55 years), younger farmers had more extension contacts ($Exp \beta = 2.5$), whilst extension contacts of executive committee members were increased by 40% ($Exp \beta = 1.4$). Altogether, the study recommends strengthening supportive services to minimize the ineffectiveness in the extension system.

Keywords: Effectiveness, Extension, Factor analysis, Poisson regression

IMPACTS OF PRESENT AGRICULTURE ON TANK ECOSYSTEMS IN SIWALAKULAMA CASCADE, SRI LANKA

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Land encroaching for cultivation and living purposes are leading reasons for deterioration of tank cascade systems threatening to their ecological integrity. This study evaluates the effect of present agriculture on the tank ecosystem in *Siwalakulama* cascade, *Galenbindunuwewa*, *Anuradhapura*. A sample of 120 households was randomly selected from four Grama Niladhari divisions in *Galenbindunuwewa* divisional secretariat division. Data were collected using a pre-structured questionnaire to ascertain the willingness to conserve of tank ecosystem and to compare past and present situations of vegetation in *Kattakaduwa* and *Gasgommana* areas. Data were analysed using a skewed logistic regression and descriptive methods. Further, water samples were collected three times from *Siwalakulama* tank after rainy season to assess physicochemical parameters. pH, EC, TDS, (NO₃⁻-N), (PO₄³⁻-P) and As, Cd, Hg were measured using standard procedures and, compared with the FAO irrigation water quality standards and WHO drinking water quality guidelines. Results revealed, tertiary education level ($p=0.031$), farming as an occupation ($p=0.027$), farming experience ($p=0.017$) have positive significant ($p<0.05$), impacts on willingness to conserve of tank ecosystem. The tested water quality parameters were within the permissible limits of FAO irrigation water quality standards. The mean value of lead (Pb) (0.01mg/L) in water samples was found as similar to the WHO standards(0.01mg/L). Also, there is a difference in vegetation between present and 20 years ago. For tank rehabilitation, 99% of respondents recommend to remove sediments of the tank and 53% recommend to restoration of *Kattakaduwa* and *Gasgommana* areas with commercial perennials. The results revealed that, there is an impact on present agriculture on the tank ecosystem of *Siwalakulama* cascade. The water can be utilized for agricultural purposes during the study period, but not for the drinking purpose. The study recommends to minimize the pollutant loading from farmlands and restoration of tank ecosystem for the sustainable utilization and conservation of the cascade.

Keywords: Tank cascade system, Tank ecosystem, Water quality

**FACTORS INFLUENCING SMALLHOLDER VEGETABLE FARMERS'
ADAPTATION TO CLIMATE CHANGE: A CASE STUDY IN NORTH
CENTRAL PROVINCE, SRI LANKA**

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The smallholder vegetable farmers are highly dependent on rainfall and temperature for their agricultural needs hence are vulnerable to climate change. Vegetable production of the country dropped by 9.1% in 2017 due to adverse weather conditions. Adaptation is the key strategy to mitigate adverse effects of climate change on agriculture. Therefore, this study was designed to explore the factors affecting smallholder vegetable farmers' adaptation to climate change in Anuradhapura district. A pre-tested structured questionnaire was used to collect data from 150 respondents selected using multi-stage random sampling technique from three divisional secretariats. An index for climate change adoption was developed using Weighted Principle Component (WPC) method by categorizing similar adaptation strategies. Multiple Linear Regression model was used to identify the factors affecting different adaptation strategies. According WPC, six climate adaptation strategies were identified namely crop diversification, soil and water conservation, changing crop calendar, flood prevention, irrigation practices and off farm activities. Results of the regression analysis revealed age ($p < 0.05$), land ownership ($p < 0.1$) and use of extension service ($p < 0.1$) significantly increase the use of crop diversification strategies while only age ($p < 0.1$) significantly increase the use of flood prevention strategies. Use of soil and water conservation strategies are significantly increased by gender and age ($p < 0.05$) while engaging in off farm activities is positively influenced by household size and type of employment ($p < 0.1$). Gender ($p < 0.1$) and household income ($p < 0.05$) significantly affect the increased use of irrigation strategies. This study recommends that programs on climate adaptation strategies should consider the heterogeneity of the population and develop tailored programs meeting the diverse needs of different population segments. Moreover, future government policies need to focus on strengthening smallholder farmers' adaptive capacity through providing access to climate related information.

Keywords: Adaptation strategies, Climate change, Limitations, Smallholder vegetable farmers

PRODUCTION OF A VIDEO-DOCUMENTARY TO MOTIVATE FARMERS TOWARDS CLIMATE-SMART AGRICULTURAL PRACTICES IN THE DRY ZONE CASCADE, SRI LANKA

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Agriculture being highly dependent on climate, farmers who are engaged in agriculture-related livelihood activities have become vulnerable for the changes in the climate. Adopting climate-smart agricultural (CSA) practices is identified as one of the strategies to minimize the adverse effects of climate change. CSA being a new concept, awareness programs related to CSA need to be planned to motivate farmers towards adapting CSA. This study aimed at promoting the CSA concept through the production of an audio-visual material. In the pre-production phase, a survey was conducted in *Sivalakulama* and *Bandarakubukwewa* cascades to identify the level of awareness about CSA. According to the findings of the survey dramatic, personal, motivational and educational message treatment dimension combination was selected to develop the concept for the video. Field video recordings were conducted in the production phase. In the post-production phase, the video was evaluated with 35 graduates. Majority of them strongly agreed that the video was attractive (71%), understandable (77%), of good visual quality (63%), appropriately disseminate knowledge (89%), motivate farmers towards CSA (74%) and of good overall quality (86%). To evaluate the effectiveness of the video among farming communities, another survey was conducted with 35 rural farmers. The attitude and knowledge change before and after watching the video was tested using paired t-test. After watching the video about 91% of farmers were willing to practice CSA in the future ($p < 0.05$). To ensure understandability of the video a pooled t-test was conducted between farmer's and graduate's responses. Understandability and attractiveness of visuals and dialogues were not significantly different ($p > 0.05$), suggesting suitability of this video to disseminate and motivate farmers towards adopting CSA. Translations of this video in Tamil and English and making them available in public and social media is recommended.

Keywords: Audio-visual, Climate change, Climate-smart agriculture, Dry zone, Video production

COMMUNITY PERCEPTION ON SUSTAINABLE UTILIZATION OF KADUWELA WETLAND FOR AGRICULTURE, SRI LANKA

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Wetland agriculture is one of the significant farming systems in many developing countries with lack of cultivable lands and increasing population. *Kaduwela* wetland is such an important wetland situated in Western Province of Sri Lanka. Production of paddy and other crops of nearby farming community are affected due to water scarcity during *Maha* season and flooding during *Yala* season in *Kaduwela* wetland area. A questionnaire survey to collect primary data was done using 120 farmers to identify the community perception towards sustainable utilization of *Kaduwela* wetland for agriculture. Qualitative and quantitative analysis were used in data analysis. Results revealed that, 57% of the farmers are willing while 43% of the farmers are not willing to cultivate crops in the wetland. Majority of the farmers (87%) who like to cultivate upland crops were males. Majority of the farmers (78%) utilized their home gardens (< 1 ac) for upland crops. Factor analysis proved that, constraints in supportive services, irrigation issues, marketing problems and lack of technology as the major constraints in adaptation of wetland cultivation. Land extent {Odds Ratio (OR)=0.387}, knowledge on environment friendly farming practices (OR=0.070), knowledge on traditional farming practices (OR=14.696), farming experience (OR=1.126), and access to extension services (OR=0.202) were recognized as significant factors ($p<0.05$) influencing the adaptation for wetland cultivation whereas the occupation (OR=0.358) was significantly influencing at 10% significant level. The study also revealed that coping strategies like mixed cropping, intercropping, crop rotation, ridge and furrows, raised beds, incorporation of soil amendments, agroforestry practices with water logging condition, tolerant species and water conservation strategies are needed for sustainable utilization of *Kaduwela* wetland for agriculture. The study concludes that the majority in the community is willing to cultivate using suitable coping agricultural strategies in order to sustainably use the *Kaduwela* wetland for agriculture.

Keywords: Agriculture, Community perception, Wetland cultivation

**INFORMATION NEEDS AND SEEKING BEHAVIOR OF MINOR
IRRIGATION PADDY FARMERS TO MANAGE CLIMATE RISKS IN
ANURADHAPURA DISTRICT, SRI LANKA**

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A significant gap existing between available information of advanced technology in agriculture and what farmers actually practice to mitigate climate risks increases the vulnerability of minor irrigation paddy farming systems. This study aimed to investigate farmers' information needs, the determinants of information utilization and the constraints contributing to information seeking behavior in *Anuradhapura* district. Stratified random sampling method was used to select 200 paddy farmers in minor irrigation systems to conduct the questionnaire survey. Descriptive and quantitative analysis were occupied in data analysis. Descriptive statistics revealed that, majority of the respondents are males (67%), literate (94%) and representing the age group of 51-66 years (46%). The majority (65%) has paddy lands less than 2 acres. The most needed information by the respondents were information on extension services (75%), rain water harvesting methods (74%), climate and weather forecasting (65%), newly improved varieties (59%), weed control techniques (57%) and paddy storage and paddy marketing plans (57%). The Garret's ranking method identified the significant challenges for climate change adaptation as wild animal attacks, lack of access to finance, high cost of adaptation measures, poor access to farm inputs and lack of awareness on information communication technology respectively. According to logistic regression results, respondents' age {Odds Ratio (OR)=0.941}, gender (OR=0.434), education level (OR=23.020), land extent (OR= 1.773) and participation for training (OR= 2.692) are significantly ($P<0.05$) influencing the information seeking behavior of them. Moreover, most severe constraints contributing to information seeking behavior were lack of awareness of information sources (69%), lack of finance (60%), lack of infrastructure (50%), and language barrier (42%) since many information comes in English language. Therefore, the study suggests the need of improvements in private and public extension services to make farmers aware on updated information sources and motivate farmers to seek more information in order to mitigate climate change risks of minor irrigation paddy farming systems in *Anuradhapura* district.

Keywords: Climate change, Information needs, Paddy farming system,

**SUSTAINABILITY ASSESSMENT OF WETLAND PADDY
ECOSYSTEM IN URBAN *KADUWELA* AREA, SRI LANKA**

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Riverine wetlands are known as one of the most productive ecosystems in the world and have been used for paddy cultivation for eras. *Kaduwela* wetland ecosystem is one of such wetlands in Colombo district of Sri Lanka and situated in western part of the *Kelani* River basin. Long term intensive paddy farming practices have led to loss of original characteristics of this natural wetland ecosystem. This study attempted to assess the sustainability of *Kaduwela* wetland paddy ecosystem and farmers' perception on ecosystem services. A questionnaire survey was conducted for 100 paddy farmers of '*Mahasen* farmer organization'. Data were analysed using multiple linear regression. Total sustainability index (TSI) for the paddy farmers with social, economic and environmental components was calculated. Results revealed that only 3% of the farmers are sustainable ($TSI \geq 0.5$) while 97% ($TSI < 0.5$) are vulnerable. Regression results revealed that, profitability, farmer education level, frequency of extension services, women participation in agricultural activities, hired labour/acre and farming experience are significantly ($p < 0.05$) influencing on adoption of sustainable agricultural practices by the paddy farmers in the area. Farmers identified flood controllability and provision of habitats for flora and fauna as the most important services from this ecosystem. Overall results emphasized that, though there are significant drives for sustainability in the system, there are less adoption of sustainable agricultural practices among the farmers due to less government intervention, less availability of organic manure and lack of extension services for the farmers. The study concludes that the *Kaduwela* wetland paddy ecosystem is vulnerable for degradation due to lesser adoption of sustainable agricultural practices by paddy farmers. Hence, the study suggests the need of government support and intervention in promoting sustainable agricultural practices for maintaining ecosystems services in *Kaduwela* wetland paddy ecosystems in Sri Lanka.

Keywords: Ecosystem services, Paddy farming system, Sustainability, Wetland

A MODEL TO CALCULATE WOMEN'S CARE ECONOMIC VALUE IN HOUSEHOLDS: A CASE STUDY IN KANDYAN HOME GARDENS, SRI LANKA

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Women's primary role as care givers in the domestic sphere is not valued yet economically. Women's involvement in home gardening for household consumption is one of the care role dimensions that attempted to value in this study. The sample consists of 120 female *Kandyan* home gardeners, were selected from *Medadumbara* Divisional Secretariat Division in *Kandy* district using multistage sampling. A pre-tested questionnaire was administered for data collection and MS-Excel Software (2010) was used for data analysis. The concept of opportunity cost was applied to calculate the forgone income for the respondents from home gardening due to her involvement in other care economic activities at home. The real labour market values were used to calculate it. The study considered six most common activities pertaining to home gardening and its relationship to consumption along with six other domestic activities performed by a typical woman in the area. The labour-days spent for all activities by a woman and prevailing daily labour wages in the study area were accounted in calculations. The selected most common domestic activities included caring for child/elderly/sick, meal preparation, washing/laundry, housekeeping, fuel-wood collection, and home-decoration. A weightage factor was adjusted to each considered home gardening activity considering the relatedness (as a percentage) of personal labour contribution to consumption. The total of the mean cost of labor of selected home gardening activities for consumption (LKR 4,488) and mean cost of labour of selected domestic activities (LKR 42,057) per month were interpreted as the care economic value in the sample and it is LKR 46,545. The total monthly income level of approximately 74% of the respondents in the sample is in the range of LKR 25,000 –50,000. Based on the results, the study concludes that the women's care role has a significant economic value. Therefore, valuation of women's care role and developing reliable methods and tools for such valuation are very important. These measures will eliminate the belief of women's domestic work has no value.

Keywords: Economic value, *Kandyan* Home gardening, Women's care role

**HOME GARDENING FOR FOOD SECURITY AND INCOME
GENERATION OF WAR AFFECTED WOMEN-HEADED FAMILIES IN
CHEDDIKULAM, SRI LANKA**

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Home gardens (HG) are dynamic and sustainable food production systems, which have been reported as an older land use system next to shifting cultivation in Sri Lanka. It plays a vital role in supporting households through providing foods, fuel wood, building materials, fodder for livestock, and generation of income. Home gardening was introduced as a viable strategy to ensure food security and income generation method among unemployed women-headed families in *Cheddikulam*, Northern Province of Sri Lanka to mitigate the effects occurred due to lasted civil war in the area. This study was conducted to assess the role of HG in food security and income generation of war affected women-headed families in *Cheddikulam*. Hundred home-gardening women-headed families in *Cheddikulam* divisional secretariat were randomly selected. Primary data were collected through pre-tested questionnaire, key personal interviews and focus group discussions and analyzed quantitatively and qualitatively. Both Shannon Wiener diversity index (SWDI) and Simpson's diversity index (SDI) were calculated. The SWDI obtained a value of 0.6723, while SDI obtaining a value of 0.4999 eliciting higher agro biodiversity in HG. Further, paddy was reported as the most dominant annual crop species (SDI = 0.1994) and banana was recognized as highest dominant species (SDI = 0.0743) among perennial in HG. Results revealed that contribution of HG for the monthly income of the households is 24.45%, which is a considerably a higher value. Further, average household dietary diversity score (HDDS) of the population was 7.31 and 66% members belonged to highly food secured group (HDDS>6.5). Results conclude that the contribution of home-gardening for food security and income generation is considerable in women-headed war-affected families in *Cheddikulam*. Hence introducing home gardening to potential other rural localities would be a worthy investment for ensuring food and income security of rural livelihoods in Sri Lanka.

Keywords: Food security, Home gardening, Income generation, Women-headed families

**EXPLORING THE PERCEPTION OF LOCAL COMMUNITY AND
POTENTIAL TO INTRODUCE AGRO-TOURISM IN *PALUGASWEWA*
TANK CASCADE SYSTEM**

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The process of attracting visitors and travellers to agricultural areas is known as Agro-tourism. It also can be recognized as a strategy that can enhance rural agricultural livelihoods. Sri Lanka as an agricultural country has many potentials to promote Agro-tourism aiming sustainable rural agricultural development. The Cascaded Tank Village System (CTVS) is a connected series of tanks organized within a meso-catchment of the dry zone landscape. This is mainly used for storing, conveying, and utilising water from an ephemeral rivulet. There are high biodiversity, agricultural lands and scenic beauty around the CTVS. Hence, there is a huge opportunity to involve in Agro-tourism activities in these areas. However, occupants in CTVS seem having lesser awareness and interest in Agro-tourism in it. Thus, the objective of this research was to explore the potential and perception of local community to develop sustainable Agro-tourism plan in *Palugaswewa* CTVS which was recently nominated as a world heritage. Simple random sampling method was used to select 234 respondents. Collected data through field survey, focus group discussions and key personnel interviews were analysed by SAS and Minitab. Logistic regression results revealed that, gender [Odds Ratio (OR)=2.849], primary occupation (OR=3.284), engaging in tourism activity (OR=6.333), awareness about upcoming Agro-tourism plan in *Palugaswewa* (OR=8.106) are significantly ($p<0.05$) affecting the participation for Agro-tourism by the villagers. The factor analysis revealed that social, social welfare, environmental and land associated factors are significantly ($p<0.1$) affecting for community perception on Agro-tourism. According to the thematic analysis, CTVS itself, wild animal tours, nearby *Habarana* and *Ritigala* tourism hotspots, traditional agricultural practices, available ancient ruins in the area and infrastructure facilities are some potentials and possible ventures for Agro-tourism in the area. Therefore, there is a potential for introducing a sustainable Agro-tourism strategy in *Palugaswewa* cascade in Sri Lanka.

Keywords: Agro-tourism, Cascaded tank village system, Logistic regression, Social welfare



Animal Production and Technology

INCLUSION OF WATER HYACINTH (*Eichhornia crassipes*) AS A PREBIOTIC ON YEAST (*Saccharomyces cerevisiae*) BASED FEED FOR GUPPY (*Poecilia reticulata*) JUVENILES

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The use of probiotic and prebiotics in aquaculture has been less investigated. This experiment focused on determining the growth performance and stress tolerance of guppy juveniles (*Poecilia reticulata*) by inclusion of water hyacinth (*Eichhornia crassipes*) as a prebiotic on baker's yeast (*Saccharomyces cerevisiae*) based feed. Six diets (crude protein $47 \pm 0.27\%$) were used as treatments with three replicates. Treatment C1 and C2 were considered as controls while T1, T2, T3 and T4 had a paste of water hyacinth 0.5%, 1.0%, 1.5% and 2.0% levels, respectively. A percentage of 1.5% yeast was used in treatments, except C1. Three weeks old fishes with an average body weight (BW) (0.10 ± 0.02 g) and an average standard body length (SL) (1.46 ± 0.03 cm) were randomly distributed at a stocking rate of 1 fish per liter. Fishes were fed twice a day for 10 weeks. Temperature ($25 - 28^\circ\text{C}$), nitrite nitrogen (0 mgL^{-1}), pH (6.5 - 8) and volume of water (40 L) were maintained in aquarium condition. The average (BW) of the fish was measured weekly and the average (SL) was measured at the beginning and end of the experiment. At the end of the experiment, osmotic stress resistance and color differences of fish were analyzed. Specific growth rate (SGR), length gain (LG), weight gain (WG) and condition factor (K) were calculated. Treatment T3 exhibited a significantly higher ($p < 0.05$) BW (0.44 ± 0.01 g), SL (3.07 ± 0.02 cm), LG ($94.19 \pm 5.59\%$), WG ($299.39 \pm 11.51\%$) and SGR ($1.98 \pm 0.04\% \text{ day}^{-1}$). Further, the guppies in T3 had a significantly higher ($p < 0.05$) stress resistance than C1 within an hour. Fish color and K were not influenced ($p > 0.05$) by the treatments. Hence, inclusion of 1.5% of water hyacinth on yeast based feed enhances the growth performance and stress resistance in guppy juveniles.

Keywords: *Eichhornia crassipes*, Prebiotic, Growth performance, Stress tolerance

EFFECT OF DIETARY PROBIOTIC, PREBIOTIC AND SYNBIOTIC SUPPLEMENTATION ON PERFORMANCE, CARCASS TRAITS AND BLOOD SERUM PARAMETERS IN BROILER CHICKEN

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Excessive fat deposition in the broiler carcass considered to be a waste of dietary energy, is an unfavorable trait for both producers and consumers. Therefore, the present study was conducted to evaluate the effect of dietary probiotic, prebiotic and synbiotic supplementation on growth performances, carcass traits and blood serum parameters in broiler chicken. Two hundred (200) day-old broiler chicks were randomly assigned into four treatments in a completely randomized design with four replicates for each treatment. Basal feed (Control), basal feed with prebiotic, basal feed with probiotic and basal feed with synbiotic were used as treatments. Growth parameters were measured weekly. Blood serum parameters, meat quality characteristics, and abdominal fat were measured at slaughtering on d 42. Data were analyzed using the Mixed Analysis of Variance in SAS. Feed conversion ratio, total feed intake, dressing percentage, the weight of carcass parts and internal organs, total cholesterol, low-density lipoproteins, high-density lipoproteins, triglycerides, and very low-density lipoproteins were not differed significantly ($p>0.05$) among the treatments. The abdominal fat content was significantly lower ($p<0.05$) in the probiotic-fed group and carcass weight also showed a significant difference ($p<0.05$) among the treatments. Water holding capacity, pH and meat color, were not significantly different ($p>0.05$). *Lactobacilli* and *Coliform* population in the cecum content were not differed significantly ($p>0.05$). However, the synbiotic-fed group showed a significantly higher ($p<0.05$) feed intake during the age of 2nd week. Average body weight gain of the synbiotic fed group was significantly higher ($p<0.05$) during the age of 2nd and 3rd weeks. This study revealed that supplementation of probiotic, prebiotic and synbiotic to broiler diet did not cause any significant change in broiler performance, meat quality, and blood serum parameters. However, probiotic incorporated basal feed seems to be a better solution for the reduction of excessive fat deposition in the abdomen.

Keywords: Abdominal fat, Broilers, Prebiotic, Probiotic, Synbiotic

THE EFFECTS OF A NEW TOTAL MIXED RATION ON THE PRODUCTION PERFORMANCES OF MILKING COWS

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A lactation trial was conducted to determine the effect of total mixed rations (TMRs) on production performances of lactating dairy cows reared under intermediate zone. Eighteen Holstein Frisian crossbred cows were blocked according to the body weight into Randomized Complete Block Design and randomly assigned into two treatments: new total mixed ration (Treatment 1) and existing total mixed ration (control) having three cows per block and three blocks per treatment. Milk yield and feed intake were measured daily and milk composition, body weight and body condition score were measured fortnightly. Nutrient composition of TMRs were evaluated. Economic efficiency was calculated by a cost benefit analysis. Gross energy content of new TMR and existing TMR were 4304.35 and 4216.91 kcal/kg respectively. Crude protein content of new TMR and existing TMR were 8.17 ± 0.19 % and 7.46 ± 0.192 % respectively. Body weight, body condition score and body weight gain were not significantly different ($p > 0.05$) between the two treatment groups. However, milk yield was significantly higher ($p < 0.05$) in animals fed with new TMR (12.01 ± 0.24 L) than those fed with the existing TMR (10.15 ± 0.24 L). Milk fat, protein and solid non-fat content (SNF) were significantly higher ($p < 0.05$) in new TMR fed group. Higher profit (Rs 419.60/cow/day) was recorded for the new TMR fed group compared to the control group (Rs 197.30/cow/day). The results revealed that, new TMR (Treatment 1) showed a significant impact on milk yield, milk fat, protein and SNF which contributed to the profit. Thus, it can be concluded that the farm can maximize the profit by replacing existing TMR with the new TMR.

Keywords: Dairy cows, Milk composition, Milk yield, New Total Mixed Ration

PROBIOTIC VIABILITY IN YOGHURT PRODUCED USING COW MILK FROM DIFFERENT CATTLE BREEDS

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Declining of probiotic viability in dairy products with storage period is one of the problems which hinder possible health benefits for the consumers. Thus, the objective of this study was to evaluate the viability of *Bifidobacterium animalis* subsp. *lactis* (BB-12), *Streptococcus thermophilus* (ST) and *Lactobacillus bulgaricus* (LB) in set type yoghurts produced using cow milk of three cattle breeds namely *Thamankaduwa* white (TW), Local “*battu*” cattle and *Sahiwal* which are commonly found in dry zone, Sri Lanka. Yoghurt samples were prepared using thirty milk samples from each breed and tested for physicochemical properties including pH, titratable acidity, syneresis and water holding capacity. Sensory evaluation was undertaken to evaluate the organoleptic properties with 30 untrained panelists. Parametric and nonparametric data were analyzed by one-way ANOVA using a completely randomized design and Friedman test respectively. The lowest syneresis and the highest water holding capacity was recorded in yoghurts produced from TW breed. As well as, the highest viability of LB, ST and BB 12 was observed in yoghurts produced from TW breed. However, BB 12 and LB viability were significantly higher in set yoghurts produced from TW breed at the last 14 days of the storage period and average counts of BB-12 and LB were 8.32 log cfu/mL and 8.30 log cfu/mL respectively. It exceeds the expected probiotic viability for set yoghurt by Sri Lankan standards institute. The pH and titratable acidity were not significantly different ($p>0.05$) among the treatments. Sensory evaluation results revealed that yoghurts produced from TW breed had the highest ($p<0.05$) sums of rank for mouth feel and overall acceptability. Hence, it can be concluded that milk of TW cattle has superior characteristics for set yoghurt production in terms of probiotic viability as well as consumer acceptance.

Keywords: Probiotic viability, Set yoghurt, Shelf life, *Thamankaduwa* white

**EFFECT OF PROTEASE SUPPLEMENTATION ON GROWTH
PERFORMANCES, CARCASS AND MEAT QUALITY
CHARACTERISTICS OF BROILER CHICKENS FED WITH LOW
PROTEIN DIETS**

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Feeding low dietary crude protein (CP) with different levels of supplemental protease enzyme on growth performances, carcass and meat quality characteristics of commercial broilers were investigated. Three-hundred, day-old Cobb 500 broiler chicks were randomly divided into five dietary treatments expanded with six replicates containing 10 chicks per each in completely randomized block design. The experimental diets were based on basal diet supplemented with protease enzyme which were, positive control (contain recommended CP levels, T₁), negative control (level of CP reduced by 5%, T₂), negative control + 300 gt⁻¹ protease (T₃), negative control + 400 gt⁻¹ protease (T₄) and negative control + 500 gt⁻¹ protease (T₅). Growth performances were observed during the study period. Carcass quality parameters and serum lipid profile were measured at slaughtering on day 42. Data were analysed using one-way Analysis of Variance in Statistical Analysis System. The highest and the lowest feed intakes were reported in birds fed with T₃ (5113 ± 61 g), and T₁ (4677 ± 61 g), respectively. The highest live weight (2.86 ± 0.07 kg), weight gain (2663 ± 54 g) and the lowest feed conversion ratio (1.84 ± 0.06) were observed in birds fed with T₅. The significantly ($p < 0.05$) highest breast (45.49 ± 1.70%) and thigh (37.05 ± 2.28%) percentages were recorded in birds fed with T₁ and T₃, respectively. There was no influence ($p > 0.05$) of treatments on NH₃ emission of litter, dressing percentage, meat quality and blood serum parameters. The feed cost spent to produce 1 kg of live weight and sellable carcass weight was significantly less ($p < 0.05$) in T₅. Thus, it can be concluded that low protein diets supplemented with protease enzyme at 500 gt⁻¹ support better growth performances in broiler chicken with lower cost of production.

Keywords: Broilers, Low protein diets, Performances, Protease enzyme

Food and Postharvest Technology



QUALITY ASSESSMENT OF DEEP FRIED NILE *TILAPIA* (*Oreochromis niloticus*) IN COCONUT AND PALM OIL

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Tilapia is one of the commonly produced inland fish type in Sri Lanka and Nile *tilapia* is the major type in commercial cultivation. Deep frying is popular among Sri Lankan consumers over other processing methods of *tilapia*. However the information on effect of different oils use or deep-frying is not adequate. Thus the present study was conducted to compare the moisture, ash, fat, peroxide value (PV), and free fatty acid (FFA) of Nile Tilapia, deep-fried in coconut and palm oil. The experiment was arranged in Complete Randomized Design with four replicates where raw fish was used as the control. Moisture, ash, fat and FFA were significantly ($p < 0.05$) different in deep fried filets compare to raw fish. Moisture content and crude fat content were significantly ($p < 0.05$) different between the fish fillets fried with both palm (44.08% and 17.25% respectively) and coconut oil (49.05% and 13.51% respectively) as well as in raw fish fillet (80.03% and 1.69% respectively). Ash content of deep fried fish filets using coconut oil (1.581%) and palm oil (1.685%) was significantly higher than that of the raw fish (1.293%). The PV were insignificant between treatments. FFA of deep fried fish fillets using coconut oil (0.812% as oleic) and palm oil (0.833% as oleic) was significantly lower than that of the raw fish (1.403% as oleic). The results highlighted that the absorption of oil during deep frying of Nile *tilapia* is significantly lower in coconut oil than that of the palm oil. However, FFA and PV were not affected by the oil type during deep of Nile *Tilapia*.

Keywords: Deep-fat frying, Fish fillets, Nile *tilapia*, Oil uptake, Oxidation

DEVELOPMENT OF RICE-BASED MILK ALTERNATIVE INCORPORATED WITH *ANNONA* AND *MORINGA*

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Rice-based milk alternative (RMA) is suitable for vegans and people suffering from milk allergy. *Annona* (*Annona muricata*) and *moringa* (*Moringa oleifera*) are rich in nutritional and sensory properties. The objective of this study was to develop and evaluate RMA incorporated with *annonna* and *moringa*. Rice-based milk alternative was developed using AT 309 rice variety and different concentrations (v/v) of *annonna* (25, 50 and 75%) and *moringa* extracts (5, 10 and 15%) were added separately to develop two RMA. The experiments were conducted in Complete Randomized Design. Developed products were evaluated for colour, odour, taste, appearance, and overall acceptability using nine-point hedonic scale. Then proximate composition of all formulations was analyzed and shelf-life was tested by measuring the pH and microbial count for a period of eight weeks. Sensory data revealed that RMA containing 10% *moringa* and 75% *annonna* had the highest overall acceptability. The 10% *moringa* incorporated RMA contained $10.04 \pm 0.04\%$ protein, $2.66 \pm 0.05\%$ fat, and $3.24 \pm 0.06\%$ ash. Its protein content was significantly higher ($p < 0.05$) compared to the RMA containing 5% *moringa*. Moreover the 75% *annonna* incorporated RMA contained $6.06 \pm 0.08\%$ protein, $0.29 \pm 0.14\%$ fat, and $1.56 \pm 0.06\%$ ash. Its protein content was significantly higher ($p < 0.05$) compared to the RMA containing 25% *annonna*. No significant difference ($p > 0.05$) was observed in pH value among three *moringa* incorporated RMA while pH value of *annonna* incorporated RMA was significantly different ($p < 0.05$). Total plate count, yeast and mould were not detected in all RMA packed in aluminum bags during 8 weeks of storage time at room temperature. Therefore, it can be concluded that 10% of *moringa* and 75% of *annonna* can be incorporated to develop RMA with desired physico-chemical, sensory and microbiological properties.

Keywords: *Annona*, Milk alternative, *Moringa*, Rice

EFFECT OF INCORPORATION OF *KITHUL* FLOUR ON PHYSICAL, MICROBIOLOGICAL AND SENSORY ATTRIBUTES OF PROBIOTIC SET YOGURT

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The present trend of consumers to choose functional food containing natural ingredients. In this study, set yogurts were developed by incorporating four levels (0.25%, 0.5%, 1% and 1.5% (w/v)) of *Kithul* (*Caryota urens*) flour (KF) in order to evaluate its effect on physicochemical, microbiological and sensory properties of set yogurt. Gelatine incorporated yogurt and yogurt without any added ingredient (control) were used to compare the results. The commercial thermophilic yogurt cultures and *Bifidobacterium bifidum* (BB12) were used for yogurt production. Samples were stored at the 4°C for 21 days and physicochemical and microbiological properties were analysed by weekly intervals. Proximate analysis of both extracted KF and yogurts were evaluated initially. Parametric data were statistically analysed using Statistical Analysis System and mean separation was done by using Tukey's test. Sensory data were analysed using the Friedman test in MINITAB. Addition of all levels of KF result in lower syneresis compared to the gelatine incorporated and the control. The incorporation of 4% (w/v) of KF showed significantly higher ($p < 0.05$) viable count of BB12 in yogurt during the storage, while the control showed the lowest viable count. Sensory data revealed that yogurt containing 0.25% (w/v) of KF led for a higher rank of appearance and odour while yoghurt with 0.5% (w/v) of KF showed the highest rank for taste, texture and overall acceptability. This study concluded that incorporation of KF has a potential to enhance the stability of yogurts and the growth of probiotic bacteria.

Keywords: *Bifidobacterium bifidum*, *Kithul* flour, Syneresis, Yogurt

EFFECT OF PRE-TREATMENT AND COOKING TECHNIQUES ON ANTIOXIDANT CAPACITY AND TOTAL PHENOLIC CONTENT OF COMMONLY CONSUMED LEGUMES IN SRI LANKA

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It is evident that the antioxidants present in legumes can be lost due to pre-treatments and cooking techniques, thus this study was planned to compare the Antioxidant Capacity (AC) and total phenolic content (TPC) of chickpea (*Cicer arietinum*), cowpea (*Vigna unguiculata*) and green gram (*Vigna radiate*) after subjecting to combinations of pre-treatments (soaking and germination) and cooking techniques (cooking using clay pot, cooking using aluminum pot, pressure cooker and microwave oven). AC and TPC were determined using 2, 2-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) assay and Folin-ciocaltue method respectively. Data were analyzed using two factor factorial completely randomized design. The untreated legumes were used as the control. In green gram, soaking followed by microwave cooking resulted the highest TPC (267.85 ± 4.54 mg GAE/100g DW) among the evaluated treatment combinations which was significantly low compared to control. Microwave cooking of green gram resulted the highest AC (2031.48 ± 400.45 mol TEAC/100g DW). In chickpea, germination followed by aluminum pot cooking showed the highest TPC (266.23 ± 8.75 mg GAE/100g DW) and AC (1756.7 ± 244.4 mol TEAC/100g DW). Both parameters were significantly low compared to the control. Germination of cowpea followed by clay pot cooking resulted the highest TPC (282.54 ± 17.51 mg GAE/100g), non-significant to the control. Germination followed by aluminum pot cooking resulted the highest AC (1403.82 ± 149.33 mol TEAC/100g DW), significantly lower than the control. According to the results of the study, germination followed by aluminum pot cooking could be recommended to preserve antioxidants and phenolic compounds in chickpea. Germination followed by aluminum pot cooking of cowpea and microwave cooking of raw green gram could be recommended to preserve antioxidants whereas germination followed by clay pot cooking of cowpea and soaking followed by microwave cooking of green gram could be recommended to preserve phenolic compounds.

Keywords: Antioxidants, Cooking, Legumes, Phenolic compounds, Pre-treatment

EVALUATION OF VARIETY EFFECT OF MUSHROOMS ON VALUE ADDED MUSHROOM PRODUCTS

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Value added mushroom products are a new concept in Sri Lanka. Therefore, a study was conducted to evaluate the effect of different mushroom varieties on value added mushroom products; mushroom fingers and mushroom spread. Mushroom fingers and mushroom spread were prepared in the laboratory using three varieties of mushrooms; Oyster mushrooms (*Pleurotus ostreatus*), *Makandura* white mushrooms (*Calocybe species*) and Abalone mushrooms (*Pleurotus cystidiosus*). Mushroom spread was packed in sterilized glass bottles and stored under refrigerated conditions. Mushroom fingers were vacuum packed and stored in freezer. The two value added products were evaluated for sensory attributes using nine-point hedonic scale, nutritional quality and shelf-life. Sensory evaluation was conducted by using 30 untrained panelists to select the best variety of mushroom for the preparation of mushroom fingers and spread. Mushroom fingers prepared using Oyster mushroom variety scored best ($p < 0.05$) for overall acceptability whereas, mushroom spread prepared using Abalone mushroom variety had the highest ($p < 0.05$) overall acceptability. Oyster mushroom fingers had a significantly higher ($p < 0.05$) crude protein ($6.71\% \pm 0.28$) and a significantly lower ($p < 0.05$) crude fiber ($0.26\% \pm 0.3$) and ether extract ($5.1\% \pm 0.31$) contents compared to Abalone and *Makandura* mushroom fingers. Abalone mushroom spread had a significantly higher ($p < 0.05$) crude protein content ($9.80\% \pm 0.19$) than the Oyster and *Makandura* mushroom spread. Total plate count and yeast and mould counts were negative and pH values were not significantly ($p > 0.05$) different for both products up to two months period. Thus in conclusion, Oyster mushroom and Abalone mushroom are the best among evaluated mushroom varieties for the preparation of mushroom fingers and spread respectively. These products can be stored up to two months without any changes in microbial properties.

Keywords: *Calocybe species*, Mushroom fingers, Mushroom spread, *Pleurotus cystidiosus*, *Pleurotus ostreatus*

DETERMINING STORAGE STABILITY OF HARD DOUGH BISCUIT POWDER

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In biscuit production, non-conforming products are generated due to minor deviations from standard quality parameters. Those waste volumes are ground to powder which is currently used as ingredients in new manufacturing cycles in biscuit industry. The quality assurance of biscuit powder during the storage is vital. Hence this study was conducted to determine the storage stability of hard dough biscuits powder (HDBP). HDBP was stored for 5 weeks and at the end of each week a soft dough biscuit (B1, B2, B3, B4, B5 respectively) was prepared using the stored HDBP. Control product (C) was prepared using freshly grounded HDBP. They were stored under accelerated conditions (40°C and 90% relative humidity) for 7 weeks to determine the shelf life. Data were analyzed as a two-factor factorial complete randomized design for physicochemical properties (moisture, pH, free fatty acids (FFA), peroxide value (PV) and p-Anisidine) and microorganisms (total plate count (TPC), yeast and mold and *Escherichia coli* counts). Sensory properties were analyzed by Friedman test. Sensory properties of B1, B2, B3 did not show any significant differences ($p > 0.05$) under accelerated conditions for 5 weeks compared to C. Moisture, FFA, PV and p-Anisidine were significantly ($p > 0.05$) higher in B3 stored under accelerated conditions for 7 weeks ($4.40\% \pm 0.02$, $0.20\% \pm 0.03$, $0.71 \text{ meq O}_2/\text{kg} \pm 0.18$ and $1.90 \text{ AnV} \pm 0.14$ respectively), compared to B3 ($1.74\% \pm 0.09$, $0.16\% \pm 0.01$, $0.12 \text{ meq O}_2/\text{kg} \pm 0.02$ and $1.25 \text{ AnV} \pm 0.35$ respectively) and the pH significantly ($p > 0.05$) decreased in B3 stored under accelerated conditions for 7 weeks (7.31 ± 0.05) compared to B3 (7.74 ± 0.01). TPC (max. 10 CFU/g), yeast (<10 CFU/g) and mold (<10 CFU/g) and *Escherichia coli* (not detected) counts were within the acceptable range of standards for biscuits. In conclusion, biscuits powder stored up to 3 weeks having desired physicochemical, microbiological and sensory properties could be used as an ingredient of biscuits manufacturing process.

Keywords: Physicochemical properties, Sensory Properties, Soft-dough biscuits

EXTENDING THE SHELF LIFE OF TJC MANGO (*Mangifera indica*) BY THE APPLICATION OF 1-METHYLCYCLOPROPENE (1-MCP)

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Mango (*Mangifera indica*) is a climacteric and highly perishable fruit. Cultivar TomEJC (TJC) is an emerging mango variety that has a huge potential in the local and export markets due to its high quality. It requires specialized postharvest handling to extend storage life. This study was conducted to extend the shelf-life of TJC mango through the application of 1-MCP. Four dosages (1ppm and 12h, 2 ppm and 12 h, 1 ppm and 24 h, 2 ppm and 24 h) were tested with the control and stored at 14°C and 85-90% RH. The flesh colour, firmness, total soluble solids (TSS), pH, weight loss, rate of respiration and ethylene production were measured at the beginning of the storage study and during the storage at four days intervals. Application of 1-MCP showed a significant effect ($p < 0.05$) on the flesh colour, firmness, TSS, pH, respiration and ethylene production. Initial a* value in the flesh changed from -7.660.41 to -7.490.83, -5.751.69, -6.660.40, -2.652.31, -0.311.99 and initial b* value 49.351.14 changed to 43.871.17, 49.681.44, 49.370.85, 55.492.12, 57.911.02 in treated samples and control respectively on 17d in storage. TSS changed from 6.830.06 to 15.10.1, 15.30.1, 15.30.1, 12.80.1 and 19.61.0. pH changed from 3.340.06 to 3.440.07, 3.430.08, 3.720.05, 4.080.08, 4.200.08 in samples while firmness decreased from 107.181.24 to 57.351.05, 91.731.30, 60.160.10, 32.720.68, 33.151.05 in the treated samples and control respectively in 17d storage. Physiological weight-loss percentage of the treated samples and the control was not significantly different ($p > 0.05$) on 17d in storage. According to the sensory evaluation and TSS, treating TJC mango with 1-MCP was found to be successful in delaying of ripening since it extended the shelf life of mango from about 10d than the untreated mango. This study concluded that application of 2 ppm of 1-MCP for 12h could be recommended to extend the shelf life of TJC mango as it keeps the mango in good quality during one month of cold storage.

Keywords: 1-MCP, Quality, Respiration rate, Shelf life, TJC mango

APPLICATION OF OZONE AS A POSTHARVEST TREATMENT FOR CONTROLLING BACTERIAL SOFT ROT IN CARROTS (*Daucus carota*)

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Soft rot in carrot caused by *Erwinia carotovora* is one of the most serious postharvest diseases in Sri Lanka. It causes severe loss, especially during storage and transit. In this study, effects of ozonated water with different concentrations (5, 10, 15, 20, and 25 mg/L) were evaluated on the growth of *Erwinia carotovora in-vitro* and *in-vivo*. Preliminary studies were conducted to determine the best temperature and pH required for the growth of bacteria. The most effective ozonated water concentration was selected based on the reduction of bacterial total plate count. The effectiveness of the selected concentration was investigated on inoculated and naturally infected 3 replicate at 30°C and 4°C. Untreated and uninoculated tubers were considered as controls. Consumer acceptability, changes of the weight, total soluble solids (TSS), firmness, titratable acidity (TA), pH and colour of the carrots were evaluated using standard methods during the storage up to 7 days at 30°C ± 2 and 65 ± 5% RH. It was observed that the ozonated water at the concentration of 200 mg/L was significantly reduced the total plate count, therefore, it was used in the *in-vivo* experiments. Reduction in bacterial soft rot was observed in the concentration of 200ppm compared to the control and other ozone levels. Further, the curative effect of ozone on bacterial soft rot was prominent at 30°C ± 2 and 65 ± 5% RH. Moreover, the TSS, TA and firmness, pH, colour of the carrots treated with 200mg ozone/L were 15 ± 0.24 °Brix, 0.56 ± 0.01% and 132.74 ± 0.32N, 13.74 ± 2%, 13.74 ± 4.58% and 45.65 ± 15.21 while, in the control 10.8 ± 0.03°Brix, 0.36 ± 0.01%, 142.73 ± 0.89N, 17.22 ± 5.74, 47.88 ± 15.96, respectively. This study reveals that the ozone can be applied as a postharvest treatment to reduce the bacterial soft rot incidences of carrots.

Key words: Carrot, *Erwinia carotovora*, Ozonated water, Soft rot

DEVELOPMENT OF A PROTOCOL FOR FREEZE PRESERVATION OF GREEN CHILLI (*Capsicum annum L.*)

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The development of an effective freeze preservation protocol for the harvested green chilli (*Capsicum annum L.*) is required to preserve production surplus of green chilli against possible quality losses and to improve its shelf life. The investigation was aimed at determining the effects of freeze preservation treatment in combination with blanching pretreatment followed by the storage at normal freezing condition ($-18^{\circ}\text{C} \pm 2$) to establish an optimum freeze preservation protocol for green chilli. Blanching and unblanching green chilli were respectively subjected to normal freeze preservation ($-18^{\circ}\text{C} \pm 2$) and blast freeze preservation ($-30^{\circ}\text{C} \pm 2$) and all the samples were kept in freezing conditions. Changes in colour, pH, total soluble solids (TSS) and total chlorophyll contents (TCC) were measured immediately after each treatment and at a weekly interval for a storage period of six weeks. The results of the four treatments were analyzed using two factor factorial completely randomized design. Parametric data were statistically analyzed using SAS and mean separation was done by Tukey's test. The colour, pH, TSS, total chlorophyll contents (TCC) were significantly ($p < 0.05$) affected by the treatments as well as with the storage time. The pH of all treatments increased significantly after six weeks of storage period. During sixth week TSS were not significantly ($p > 0.05$) different among treatments. Total soluble solids in unblanching blast frozen chilli were significantly higher throughout storage. Total chlorophyll contents were significantly higher in normal frozen chilli than in blast frozen chilli at sixth week of storage. The rating for the visual quality depicted that unblanching blast frozen chilli retained a higher acceptability throughout storage. It could be concluded that unblanching blast freezing had a potential to be utilized as a protocol to adopt in freeze preservation of green chilli

Keywords: Blanching, Blast freezing, Chilli, Normal freezing

**QUALITY ASSESSMENT OF RICE BEVERAGE MADE FROM
TRADITIONAL RICE VARIETIES FERMENTED BY *Lactobacillus
plantarum***

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This study was conducted to investigate the fermentation characteristics and suitability of traditional rice flour for fermented beverage production using four traditional rice varieties. Fermented rice beverage was prepared using *Lactobacillus plantarum* (2%) as a probiotic bacterium. Rice varieties: *Suwandel*, *Pachchaperumal*, *Kalu heenati*, and *Madathawalu* were used with 1:12 rice flour to water ratio to develop the fermented rice beverage. The best variety was selected by a sensory evaluation with thirty untrained panelists using nine-point hedonic scale after one day of production. Titratable acidity (TA), pH, Total soluble solid (TSS), probiotic counts and yeast & mould counts of the fermented rice beverage samples were tested during the storage (4°C, 3 weeks). Parametric and sensory data were analyzed using two-way ANOVA Completely Randomized Design (CRD) and Friedman test, respectively. After one day of storage, pH and TSS was significantly decrease and TA was significantly increase in all rice varieties. *Suwandel* variety resulted in the best sensory properties for color, aroma, texture, taste and overall acceptability ($p < 0.05$). There was a significantly higher pH and lower TA in *Suwandel* variety among other rice varieties. Furthermore, the TSS of *Suwandel* was significantly higher after 1 week of storage among other rice varieties. The probiotic count of all samples was beyond the threshold of minimum therapeutic value (10^6 CFUml⁻¹). There was an increase of probiotic bacteria count till 6th day of storage and decrease thereafter. Therefore, these results infer that it is healthier to consuming fermented rice beverage up to 1 week of storage period. Yeast and mold count of all rice beverage samples was within the acceptable range (< 1000 CFUml⁻¹) during the 3 weeks of storage period. According to the results, *Suwandel* variety could be effectively used to produce fermented rice beverage without quality deterioration for 3 weeks storage at 4°C.

Keywords: *Lactobacillus plantarum*, Probiotic, Rice beverage, Traditional rice varieties

DEVELOPMENT AND EVALUATION OF SET YOGHURT BY USING PROBIOTIC CULTURE (*Lactobacillus paracasei* and *Lactobacillus rhamnosus*) AS A BIO-PRESERVATIVE

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Yoghurt is one of the most popular food, produced by bacterial fermentation of milk which plays a major role in dairy industry. The objective of this study was to evaluate the effect of bio-preservative cultures (*Lactobacillus paracasei* and *Lactobacillus rhamnosus*) on physicochemical, microbiological and sensory properties of set yoghurt. Yoghurt incorporated with Potassium sorbate was used as the control. All the yoghurt samples were prepared with three replicates using fresh cow milk having 3.7% fat content with thermophilic starter cultures. Samples were stored at 4°C for 28 days and all physicochemical and microbial properties were evaluated at weekly intervals. Sensory evaluation was conducted using day old produce up to 28 days at weekly intervals. Parametric data were statistically analyzed using SAS program. The organoleptic data were analyzed by Friedman test using MINITAB. There was no significant difference ($p>0.05$) in the titratable acidity and pH between Bio preservative added yoghurt sample and the control. Sensory data revealed that replacing Bio preservative has no significance effect ($p>0.05$) on the overall acceptability of yoghurt during the storage time. Coliform was not detected and yeast (<1000 cfu/g) and mold (<1 cfu/g) counts were within the acceptable level over the storage period of 28 days at refrigerated storage. This study concluded that the Bio-preservative culture could be used instead of the chemical preservative (Potassium sorbate) in commercial yoghurt production.

Keywords: Bio-preservation, Bio-protective culture, Physicochemical properties, Yoghurt

USE OF MILK PROTEIN ISOLATE TO IMPROVE THE TEXTURAL PROPERTIES OF CURD

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Commercial curd manufactures are used to add gelatine in curd production to obtain better textural properties while avoiding the defects like poor mouth feel. However, according to food standards and Ministry of Health in Sri Lanka, addition of gelatine into curd is banned. Therefore, the objective of this study was to evaluate the effectiveness of Milk Protein Isolate (MPI) on improved textural properties of curds. Four different levels of MPI as 0.5%, 1%, 1.5% and 2% were compared with control curd sample which was produced by adding milk powder instead of MPI. Physicochemical properties including pH, titratable acidity, syneresis were measured during the shelf life of 14 days. Hardness, chewiness and adhesiveness were assessed as textural properties. Microbiological safety was analysed during the shelf life of 14 days using coliform, yeast and mold counts. Sensory evaluation was carried out using 30 untrained panellists to evaluate the organoleptic properties of curd using colour, appearance, flavour, aroma, texture and spoon ability. Parametric, nonparametric data were analysed by ANOVA in SAS and Friedman test, respectively. Results showed that all the textural properties including hardness, chewiness and adhesiveness were significantly different ($p < 0.05$) among the treatments while the highest mean values were recorded in the 2% MPI added curd samples. There was no significant difference ($p > 0.05$) for pH and titratable acidity among the treatments. Curd developed with 2% MPI had the lowest syneresis compared to other treatments. According to the sensory evaluation results, appearance, texture and spoon ability were also much better in the 2% MPI treatment. Microbiological analysis showed that coliform was not observed during the storage period while yeast and mould growth were below the safe levels in all treatments. In conclusion, 2% MPI could be effectively used to replace gelatine like constituents in curd while enhancing the textural properties and consumer acceptance.

Key words: Curd, Milk protein isolate, Spoon ability, Texture

**DEVELOPMENT OF A PROTOCOL FOR ARTIFICIAL RIPENING OF
EMBUL BANANA (*Musa* spp.) IN SRI LANKA**

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Banana (*Musa* spp.) ripening is generally practised using artificial ripening methods. However, problems are created due to overuse, time of exposure and method of application of artificial ripening agents. An experiment was carried out to develop a protocol for artificial ripening of *Embul* banana by optimizing the chemical usage and exposure time. Two-factor factorial experiment in a completely randomized design and peel appearance, flesh appearance, taste, odour and overall acceptability were assessed using a sensory evaluation using thirty untrained panelists were conducted. *Embul* banana at correct maturity were treated using three ethephon concentrations; 100, 150 and 200 ppm combined with three exposure durations; 12, 18 and 24 hours (h) in a ripening chamber. The untreated banana was used as the control. All banana was kept for 6 days at the storage temperature of 30°C ± 2. Firmness, pH, total soluble solids (TSS), ascorbic acid content (AAC), colour and total chlorophyll content (TCC) of banana were assessed in the initial day and in one-day interval basis at the storage. TSS was significantly ($p < 0.05$) higher at the 2nd day of storage in 200 ppm treated for 24 h (24.80±0.44) followed by 200 ppm treated for 18 h (21.73±1.32) compared to control (9.32±0.97). Firmness was significantly ($p < 0.05$) lower at the 2nd day of storage in 200 ppm treated for 24 h and 18 h (7.39N ± 0.73 and 12.43N ± 3.06 respectively) compared to control (38.47N±4.17). The samples treated with 200 ppm for 18 h and 24 h had 6 and 5 days of shelf life respectively, where 75% of the fruits were over ripen. Results of the sensory analysis revealed that 200 ppm treated for 18 h had the significantly ($p < 0.05$) higher consumer acceptance. Consequently, it is concluded that the ethephon concentration of 200 ppm for 18 h could be recommended dosage to accelerate ripening of *Embul* banana with longer shelf life.

Keywords: Ethephon, Exposure time, Storage duration

EVALUATION OF THE COMMERCIAL APPLICABILITY OF ORGANIC RIPENING AGENT

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Use of chemicals on artificial ripening of fresh fruits has become a debated issue and alternatives are being investigated. Previous studies have reported, leaf powder of Bilin (*Averrhoa bilimbi L.*) and Keppetiya (*Croton lacciferus L.*) 1:1 ratio induce ripening of banana. Based on the results of the previous study, this study was focused on determining the optimum amount of leaf powder mix (LPM - 1:1 ratio of Bilin: Keppetiya) per fruit weight to induce ripening of banana and to investigate its commercial applicability in small scale condition. Emanations of LPM were analyzed by gas chromatography (GC). Banana variety *Embul* was harvested at mature green stage (Total soluble solids (TSS) 7.10 0.05° Brix) and exposed to four levels of LPM, namely 0% (control), 1%, 2% and 3% per fruit weight and kept for 24 h in airtight condition. Data on peel color, firmness, TSS, Titratable Acidity (TA), pH and physiological weight loss (PWL) were measured daily until it reached to the table ripening stage. Further, banana hands were packed as small scale commercial condition and four packs of 3% LPM (w/w) were kept inside with non-treated control. After 24 h, fruits were removed and visual quality rating (VQR) and ripening index (RI) were observed daily for a week. The results revealed that ethylene gas was not detected by the GC. Further, 3% (w/w) LPM had significantly ($p < 0.05$) different peel colour ($L^* = 74.45 \pm 0.38$, $a^* = -1.63 \pm 0.24$, $b^* = 74.45 \pm 0.38$), firmness (3.63 ± 0.13), TSS (24.67 ± 0.15), TA (0.7 ± 0.01), pH (4.3 ± 0.01) and PWL (0.11 ± 0.04) than the control. However, VQR and RI of treated samples were similar to the control ($p > 0.05$). Hence, it is recommended 3% (w/w) leaf powder mix for the ripening of banana and further investigations are required at commercial scale.

keywords: *Averrhoa bilimbi*, Banana, *Croton lacciferus*, Ripening

**DEVELOPMENT OF A PROTOCOL FOR ARTIFICIAL RIPENING OF
TAINUNG NO 01 PAPAYA (*Carica papaya* L)**

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Papaya (*Carica papaya* L) is one of the demanding fruit in which both natural and artificial ripening are practiced. But use of artificial ripening agents boost ripening process followed by rapid senescence. Therefore, this study was conducted to develop a protocol for artificial ripening of papaya in order to reduce post harvest losses in destination markets. Tainung No 01 papaya in their commercial maturity were subjected to ethephon concentrations of 150 ppm, 200 ppm and 250 ppm for exposure time periods of 12 h, 18 h and 24 h in an artificial ripening chamber according to the two factor factorial completely randomized design. An untreated sample was kept as control. After giving treatment they were allowed to ripe at ambient condition ($30 \pm 2^{\circ}\text{C}$, RH 75%-85%). During the ripening period, physicochemical parameters such as peel colour, firmness, pH, Total Soluble Solids (TSS), titratable acidity, Total Chlorophyll Content and the physiological parameters such as respiration rate and O_2 emission rate were analyzed in 1 day interval. A sensory evaluation was conducted to evaluate the perception of peel colour, flesh colour, odor, taste and overall acceptability with 30 untrained panelists using five-point hedonic scale. There was a significant difference ($p < 0.05$) within the treatments and storage in all the evaluated parameters. The treatment exposed to 250 ppm for 12 h exhibited a significant decrease in firmness from 126.44 ± 5.45 to 51.2 ± 3.54 while the control decreases to 109.90 ± 8.32 after the 4th day of the treatment. Meanwhile the TSS significantly increased from 10.66 ± 0.65 to 12.07 ± 0.06 in above mentioned time period. Further, the highest sensory perception was also observed in same treatment. This result of the study reveals that 250 ppm ethephon concentration exposed for 12 h could be used in ripening of papaya in terms of safeguarding quality and storability.

Keywords: Artificial ripening, Ethephon, Papaya, Quality, Storability

DEVELOPMENT OF LESS SWEET FIBER-ENRICHED DRINKING YOGURT BY USING SOLUBLE DIETARY FIBER AS A STABILIZER

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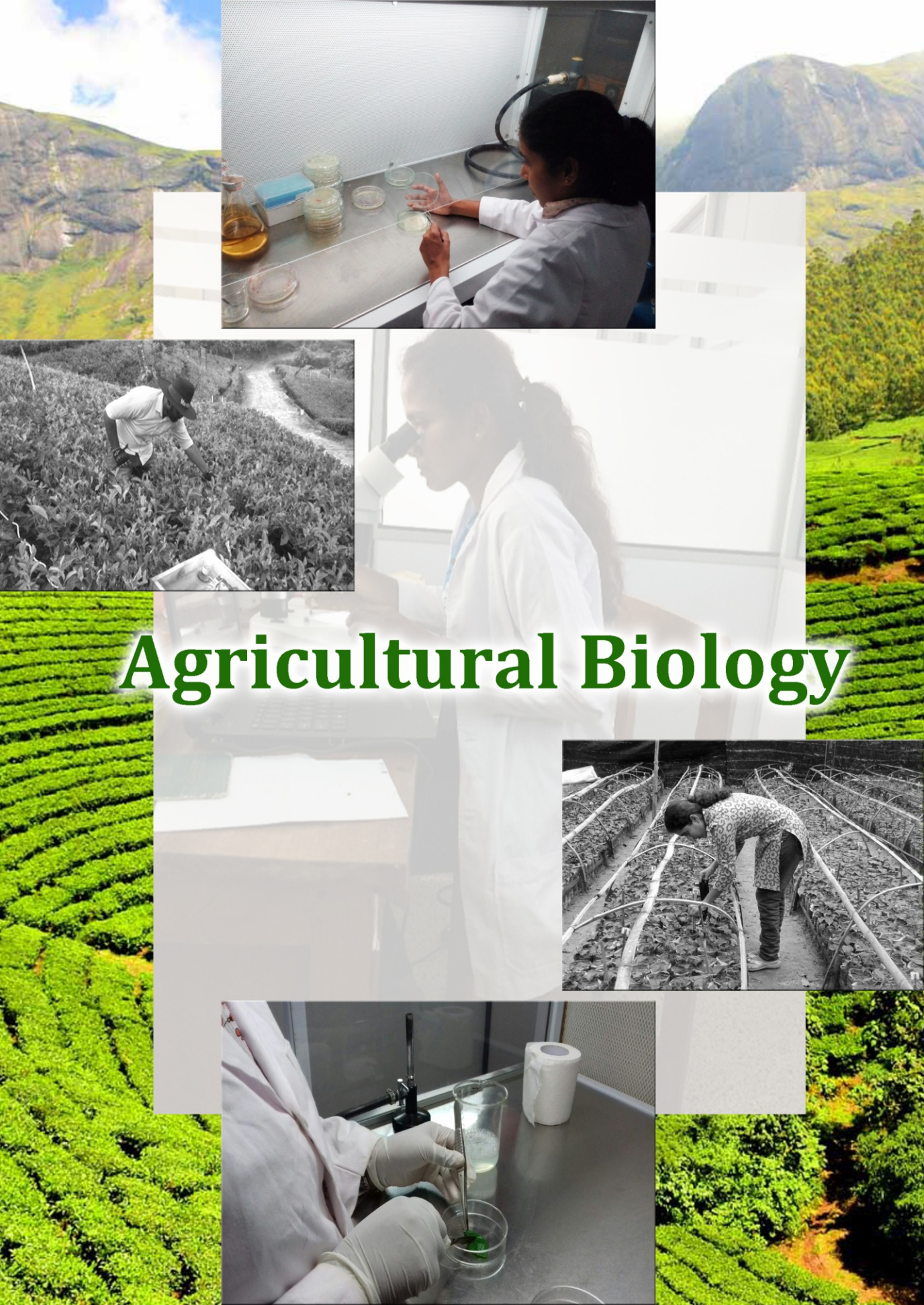
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With a growing interest in health-promoting functional foods, the demand for natural additives has increased worldwide. The aim of this study was to develop a less sweet fiber-enriched yogurt drink by adding soluble dietary fiber which is a natural stabilizing agent. First study was conducted to select the best sugar level among four different sugar levels (0, 3, 6, and 9% w/v), where 9% (w/v) was found to be the most acceptable by the sensory evaluation. The second study was conducted to evaluate the effect of soluble dietary fiber levels (3, 3.5, and 4% w/v) in terms of physicochemical and sensory properties, together with the selected sugar content for the production of a less sweet fiber-enriched yogurt. Finally, the selected soluble dietary fiber level was compared with a synthetic stabilizer, gelatin (0.45% w/v), and an authenticated control which did not contain any stabilizers. Physicochemical properties and microbiological properties of drinking yogurts were determined for four weeks of duration. Parametric and nonparametric data were analyzed using one-way ANOVA completely randomized design and Friedman test, respectively. The 3% (w/v) soluble dietary fiber level was selected among three different soluble dietary fiber levels due to its superior sensory properties. Titratable acidity, pH and brix value of 3% (w/v) soluble dietary fiber level was 0.9125 ± 0.01 , 0.43 ± 0.01 and 19.25 ± 0.05 respectively. The highest overall acceptability resulted in 3% (w/v) soluble dietary fiber incorporated yogurt drink compared to the gelatin and the control yogurt drink. Ash, protein, syneresis were significantly lower and water holding capacity was significant higher in less sweet fiber-enriched yogurt drink compared to gelatin and control yogurt drinks. *Escherichia coli* was not detected in all levels of stabilizer, while yeast and mold count of yogurt drinks were within the acceptable range (maximum 1×10^3 CFU/g) during the storage period. In conclusion, less sweet soluble dietary fiber could be effectively incorporated to develop a yogurt with desired physicochemical, rheological, microbiological and sensory properties and shelf life.

Keywords: Drinking yogurt, Gelatin, Microbiological properties, Sensory properties, Sugar content



Agricultural Biology

**INSECT DIVERSITY IN A REGENERATED FOREST, ABANDONED
CHENA AND VEGETABLE AGRO-ECOSYSTEM IN *DAMBULLA*,
SRI LANKA**

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Insects are the most diverse group of organisms in the world and they play a major role in ecosystem diversity and sustainability. The composition of plants in an ecosystem could be a major determinant on insect community because plants provide food, habitats and shelter for insects. The effect of agricultural practices on the diversity of insect fauna is poorly understood in the local context, therefore, this study was conducted to assess insect diversity and abundance in three different ecosystems; regenerated forest, abandoned *chena* and a vegetable agro-ecosystem located in *Dambulla*, Sri Lanka. Soil dwelling insects and aerial insects were collected using ten pitfall traps (200 ml) and two light traps (12V, 1.5W) installed in each location. Samples were taken after 24 hours at one month intervals. The insect abundance was compared using Poisson regression analysis and the diversity was compared using Shannon diversity and Bray Curtis similarity indices. The evenness of families was assessed using Pielou's index. A total of 2923 insects belonging to 64 families and 11 orders were collected during the study. The highest soil dwelling and aerial insect diversity was recorded in the regenerated forest ($H' = 0.726, 0.986$), followed by abandoned *chena* ($H' = 0.498, 0.878$) and vegetable agro-ecosystem ($H' = 0.380, 0.782$). The evenness of the insect fauna of regenerated forest, abandoned *chena* and vegetable agro-ecosystem was 0.677, 0.536 and 0.442, respectively. Bray Curtis similarity index of insect community between regenerated forest and vegetable agro-ecosystem was higher ($D = 54.6\%$) in compared to vegetable agro-ecosystem and abandoned *chena* ($D = 25.6\%$). The insect abundance was significantly high ($p < 0.05$) in the abandoned *chena* and vegetable ecosystem in compared to regenerated forest, however, which was not significantly different over time. It is concluded that the regenerated forests can be used to restore and conserve the insect diversity.

Keywords: Agro-ecosystem, Conservation, Diversity indices, Insect fauna,
Regenerated forest

EVALUATION OF NON-PESTICIDAL METHODS FOR MANAGEMENT OF BLISTER BLIGHT OF TEA

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Blister blight caused by *Exobasidium vexans* is a highly destructive disease of tea (*Camellia sinensis* (L.) Kuntze). The disease is mainly controlled by the frequent application of copper-based fungicides, which could lead to serious environmental and health issues. The present study was conducted to evaluate potential use of non-pesticidal methods to reduce blister blight incidences, yield performances and changes of selected biochemical parameters. Field experiments were conducted in Queensberry Estate, *Nawalapitiya* using cultivar TRI 2024 to evaluate four treatments, spraying 2% sodium bicarbonate (SB) and 1 mM salicylic acid (SA), hot air (50°C) treatment and applying copper oxychloride (2g/l) spray. Treatments were applied six times in weekly intervals and blister blight incidence was recorded at two-day intervals while, the yield data was recorded at 7th day after each application. Separately, the effect of Infra-Red and UV radiation on the suppression of blister was tested by exposing tea leaves at 3, 5, 10 seconds in laboratory. Tea leaves of treated plants with sprays were analyzed for four defense enzymes, polyphenolic content and chlorophyll *a* and *b*. Percentage blister blight incidence was significantly ($p < 0.05$) reduced by SB and SA spray treatments in comparison to the fungicide treatment, while no significant difference was observed between SB and SA. The reduction of disease incidence by SB and SA sprays was prominent from the second application onwards. Hot air treatment reduced the disease incidence significantly from the fourth application onwards. Leaves treated with Infra-Red and UV radiation was not effective as the leaf moisture content was reduced drastically. SB and SA treatments resulted significantly higher levels ($p < 0.05$) of defense enzymes, polyphenolic compounds and leaf yield. Therefore, sodium bicarbonate, salicylic acid and hot air treatments could be identified as successful non-pesticidal measures to reduce blister blight incidence of tea.

Keywords: Blister blight, Chlorophyll, *Exobasidium vexans*, Defense enzymes, Tea

SUITABILITY OF GELRITE, AGAR, ISUBGOL, THEIR BLENDS AND A LIQUID STATIC MEDIA IN *IN VITRO* PROPAGATION OF *Anubias barteri* var. *Nana*

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With the increase of aquarium keeping in worldwide, the ornamental aquatic plant industry of Sri Lanka has been developing rapidly and requires a continuous supply of high quality plants on a large scale. Although this demand could easily achieve by micro-propagation, high cost of production is one of the main barrier. Media cost plays an important role in production due to high cost of solidifying agents compared to other media ingredients. This study aims on finding a low cost medium using Gelrite, Agar, Isubgol, their blends and a liquid static medium on *in vitro* propagation of aquatic ornamental plant, *Anubias barteri* var. *nana*. Multiplication and rooting of the experimental plant was carried out using Murashige and Skoogbasal medium. Parameters such as number of shoots having more than 5 leaves, multiplication rate, root number per plant and total root length per plant were taken to evaluate efficiency of different media. No significant differences were observed among treatments ($p > 0.05$) for multiplication rate and number of shoots having more than 5 leaves per explant. However, the best multiplication rate (3.68) and the highest number of shoots having more than 5 leaves (8.167) were recorded in static liquid medium. Significant differences among treatments ($p > 0.05$) were observed in root number and total root length per plant. The highest total root length was observed in liquid static medium (33.54 cm), while the highest root number per plant (33.41) was observed in Isubgol-Agar blend (7.5 gL⁻¹ Isubgol + 3.5 gL⁻¹ Agar). However liquid static medium gave 13.81 number of roots per plant. However, apart from root number per plant, liquid static medium recorded highest results for all other investigated parameters. In conclusion, liquid static media can be used in *in vitro* propagation of *Anubias barteri* var. *nana* as low cost medium.

Keywords: Agar, *Anubias barteri* var. *nana*, Gelrite, Isubgol, Liquid static media

**DETERMINATION OF VOLATILE ORGANIC COMPOUND
PROFILES OF DIFFERENT COCONUT VARIETIES IN RELATION TO
COCONUT MITE *Aceria guerreronis* INFESTATION**

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Coconut mite (*Aceria guerreronis* Keifer) is a devastating pest in many coconut growing countries in the world. Infestation of the coconut mite has serious consequences on the economy and livelihood of people in the affected countries. Biological, chemical and physical management methods have been developed to manage the pest. However, there are issues on their practicability and cost. Therefore, cultivation of the coconut varieties which are resistant/ tolerant to coconut mite is a sustainable solution. Plant volatiles play a major role in their resistance to pest and diseases. Such information on coconut plants is scarce. This study was conducted to determine the differences in volatile compound profiles of young coconut fruits of four coconut varieties: Sri Lanka Green Dwarf and Ordinary Tall (putative susceptible varieties), and Sri Lanka Yellow Dwarf and *Gon Thembilli* (putative resistant varieties). The volatile profiles of 3-4 month old coconut fruits collected from uninfested and infested palms of the four varieties were compared to identify the changes following infestation by *A. guerreronis*. Furthermore, the volatile compounds were analyzed by using the GC-MS method. Differences in the volatile profiles were observed.

Keywords: *Aceria guerreronis*, Coconut, GC-MS, Host plant resistance, Plant volatiles

EFFECT OF ECO-FRIENDLY NURSERY MANAGEMENT MEASURES OF *Camellia sinensis* ON SOIL MICROBIAL DENSITY AND DIVERSITY

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Nursery management plays a vital role in producing healthy and vigorous tea plants for field establishment. Present study was conducted to determine the effect of eco-friendly nursery management practices on the density and diversity of microorganisms in nursery soil of tea. Soil samples were collected separately from soils, treated with two types of management practices (i.e. eco-friendly and existing) at *Kataboola* estate, *Nawalapitiya*. Composite samples were used for quantification of total bacterial and fungal counts by dilution plate technique. Bacterial diversity was determined in terms of Gram status, the ability of spore-formation, nitrogen- fixing and fluorescent pigment production using standard biochemical tests and diagnostic media. Bacteria having distinct colony morphology were subjected to molecular identification by PCR of the rRNA region, DNA sequencing and homology search. Soil pH, electrical conductivity (EC) and total dissolved solids (TDS) of the samples collected from two management practices were measured. The diversity and density of Bacteria were than that of fungi in soils under both management measures. Soils managed under eco-friendly measures resulted in higher colony diversity of bacteria (19) than the soil under existing management practices (14). Density and diversity of Gram-positive and spore- forming bacteria were higher in soils managed under eco-friendly measures (15) than in the soils under existing management (9). Diagnostic media identified *Rhizobium* spp.in both types of soils and *Azotobacter* spp. in soils under only eco-friendly management while fluorescent producing *Pseudomonads* were not detected in both soils. The soil pH, EC and TDS of the soil of the fields managed under eco-friendly measures were 6.00, 44.60 μscm^{-1} and 20.98 mgL^{-1} , respectively, while, in the existing management those were 4.0, 106.1 μscm^{-1} and 49.7 mgL^{-1} , respectively. As conclusion of the study, eco-friendly management practices could be recommended for tea nursery management in Sri Lanka.

Keywords: Diagnostic media, Dilution plate technique, Nitrogen fixing bacteria, Spore forming bacteria

OPTIMIZATION OF A PROTOCOL FOR MICRO-PROPAGATION OF *Aloe vera*

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The medicinal plant *Aloe vera* naturally propagated through suckers is insufficient to meet the global demand. Rapid micro-propagation technique plays a vital role to overcome this problem. The present investigation was launched to maximize micro-propagation rate of *Aloe vera* by using different explant materials, optimizing surface sterilization and using different concentrations of growth regulators for induction and multiplication. Suitability of two types of explants materials (Type A- stem piece with one leaf and Type B- only the stem piece) were evaluated by the survival percentage. The explants were disinfected with different concentrations of Sodium hypochlorite (15%, 20%, 25%, and 30%) dipping in 10, 20 and 30 minutes. Further, explants were treated with 70% alcohol and three concentrations of Hydrogen peroxide (5%, 10%, and 15%) to reduce the contaminations. The contamination percentage and bleaching percentage were recorded to determine the most effective surface sterilization protocol. 6-benzylaminopurine (BAP) concentrations of 2 mgL⁻¹, 3mgL⁻¹, and 4mgL⁻¹ were selected as treatments with 30 replicates for each to assess the survival percentage, multiplication rate and the number of shoots per culture. The highest survival percentage (93.28%) was recorded in Type A explants. The explants sterilized with 25% Sodium hypochlorite for 20 minutes followed by 70% alcohol and 10% hydrogen peroxide were the best surface sterilization treatments that had the least contamination percentage of 2.22%. There was no significant difference ($p>0.05$) among the survival rate of three treatments of induction. Significant difference was recorded between 2 mgL⁻¹ and 3 and 4 mgL⁻¹ of BAP for average shoot number and multiplication rate. The highest average shoot number (15.85) were recorded in 3mgL⁻¹ of BAP and the highest multiplication rate (3.0137) was recorded in 4mgL⁻¹ of BAP. It could be concluded that the protocols developed in this study can be used for the micro-propagation of *Aloe vera*.

Keywords: *Aloe vera*, Micro-propagation, Sterilization, Induction, Multiplication

**EFFECT OF ECO-FRIENDLY NURSERY MANAGEMENT MEASURES
ON GROWTH PERFORMANCES AND INDUCTION OF HOST PLANT
RESISTANCE OF *Camellia sinensis***

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Heavy dependency on chemical applications for the control of pest and diseases of tea poses threats to the quality standards of made tea. The present study was conducted in *Kataboola* estate, *Nawalapitiya*, to determine the effects of eco-friendly nursery management measures, which were introduced in the present study, on growth performances, incidence and severity of blister blight and induction of host plant resistance due to synthesis of defense enzymes, in comparison to the existing nursery management practices. Eco-friendly measures introduced by the present study included application of sodium bicarbonate, salicylic acid, sodium hypochlorite and a talc-based formulation of *Bacillus megaterium*. Shoot height, number of leaves, number of casualties, plants having active buds, plants with necrotic leaves and incidence and severity of blister blight were recorded in bi weekly intervals in three types of plant sets maintained after re-stacking. Defense enzymes namely, peroxidase, phenylalanine ammonia lyase (PAL), β -1, 3- glucanase, chitinase and total phenol content of the tender tea leaves were quantified by standard spectrophotometric methods. Findings revealed that number of casualties and necrotic lesions on leaves varied significantly due to interaction effect (type of nursery management methods x type of plant set). However, the other growth parameters varied significantly among the type of plant set but not by the type of management measures. Incidence and severity of blister blight did not differ significantly among the plant sets under two types of management. Tea leaves of the plants treated with eco-friendly measures resulted in significantly higher levels of peroxidase ($p < 0.0006$), PAL ($p < 0.0012$), β -1, 3- glucanase ($p < 0.0003$) and chitinase ($p < 0.034$). Total phenol content in tea leaves had no significant difference at $p = 0.05$. Eco-friendly measures introduced in the present study are successful in inducing host plant resistance in nursery plants of tea through activation of defense enzymes.

Keywords: Defense enzymes, Growth performance, Induced host plant resistance



Crop Science



EFFECT OF FOLIAR APPLICATION WITH UREA AND NAPHTHALENE ACETIC ACID ON GROWTH AND YIELD OF MUNG BEAN

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The foliar application of plant growth regulators and nutrients has been practiced in mung bean (*Vigna radiata* L.) for enhancement of growth and yield. However, the effectiveness of foliar sprays on mung bean is not yet studied under Sri Lankan conditions. Hence, a field experiment was conducted at the Field Crop Research and Development Institute, *Mahailuppalama* during November-April (2018/2019 *Maha* cropping season) to investigate the effect of urea and Naphthalene Acetic Acid (NAA) as a foliar application on growth and yield of mung bean. The experiment was arranged in randomized complete block design with eight treatments and three replicates. Foliar sprays; 1% urea [30, 45 days after sowing (DAS) and 20, 30, 40 DAS], 1% urea [(30, 45 DAS) and (20, 30, 40 DAS) with 40 mgL⁻¹ NAA], 40 mg/l NAA alone and spraying of water were tested combined with the recommended N, P, K fertilizers for mung bean. Treatments with NAA were applied at pre-flowering stage and 15 days thereafter. A treatment with zero fertilizers was used as the control. Plant height, canopy width, root length, number of nodules, percentage of dead and live nodules, number of leaves, leaf area, total dry weight, number of pods and seeds per pod were not significant ($p > 0.05$) among treatments. Although the SPAD readings were not significantly different among treatments until pod formation, it was significantly higher in treatments with NAA alone and 1% urea (20, 30, 40 DAS and 20, 30, 40 DAS with NAA) at 75 and 85 days after sowing. Highest and the lowest seed yield recorded were 1.93 and 1.25 tha⁻¹ respectively, while the seed yield among treatments were remained insignificant ($p > 0.05$). In conclusion, the application of urea and NAA as foliar application is not an effective method for improving the mung bean yield under the tested field conditions.

Keywords: Foliar application, Mung bean, Naphthalene acidic acid, Urea

ROLE OF SEED WATER GAP STRUCTURE IN SEED GERMINATION OF *Ficus* SPECIES FROM SOUTH CHINA

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Investigating the predictive power of seed functional traits to determine regeneration success could improve our understanding of the regeneration process and its response to future global changes. This study, using 16 *Ficus* species evaluated the predictive capacity of seed traits on seed germination success and the role of seed water gap structure during the imbibition phase of seed germination. A dye tracking experiment using seeds submerged in acid fuchsin for 20 min, followed by paraffin embedding, slicing and subsequent measurement of digital images showed that the water gap structure was the main water entry point for all species. The hilum region length and width measured by imbibing seeds for 12 h period at 25°C showed a diversity of changes from increases to decreases in its length. Seed coat thickness in the water gap structure area was different from the rest of the seed coat. Intra-specific differences between seed coat thickness was identified but without a correlation to seed germination or a differentiation between epiphytic versus terrestrial habit. Contrary to expectations, there was no correlation between the hilum length and width after 12 hours imbibition in water and the probability of germination. Correlations between all seed traits (water gap traits such as hilum length and width, and seed coat thickness in the water gap region, seed width, seed length, seed perimeter, seed area, seed coat thickness and seed moisture content) and germination success showed that germination rate was highly correlated with species' seed surface area ($p > 0.0001$) followed by seed length ($p > 0.01$) and seed width ($p > 0.01$), indicating larger seeds has higher germination probability. The seed water gap structure mattered the most for germination along with the thickness of seed coat. This study provides novel insights into the role of the water gap structure and other seed characteristics in determining seed germination.

Keywords: Dye tracking, *Ficus* species, Imbibition phase, Seed water gap structure

IMPACT OF ENVIRONMENTAL TEMPERATURE TO DETERMINE THE CROP DURATION OF SELECTED SRI LANKAN RICE VARIETIES

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Despite a large number of agronomic, physiological and modelling studies on rice (*Oryza sativa* L.), the cardinal temperatures and thermal time (TT) requirements for key developmental processes of Sri Lankan rice varieties are not known. Therefore, TT requirements for flowering and maturity of widely cultivated Sri Lankan rice varieties; Bg300, Bg352, Bg358 were studied. National coordinated rice varietal trial data from 14 locations and corresponding weather data were collected. Results showed that average number of days required for maturity of Bg300, Bg352 and Bg358 was 96 ± 5 , 99 ± 7 and 105 ± 4 , respectively. The optimal temperature for flowering and maturity of all varieties were 27.4°C while the minimal and maximal temperatures obtained from the literature were 14.5 and 35°C , respectively. TT requirements for flowering and maturity during *Yala* season were higher than those estimated for *Maha* season, *i.e.* Bg300, Bg352 and Bg358 required 1593, 1741 and 1831°Cdays for flowering during *Yala*; whereas, 1440, 1457 and 1646°Cdays for the same during *Maha*, respectively. Similarly, TT requirement for the maturity of Bg300, Bg352 and Bg358 during *Yala* were 2345, 2556 and 2588°Cdays while those during *Maha* were 2096, 2153 and 2307°Cdays , respectively. The shortest duration for flowering was observed at *Bombuwela* for Bg300 and Bg358 and *Bathalagoda* for Bg352, and the longest duration for flowering was observed at *Batticaloa*, *Vavuniya* and *Murunkkan* for Bg300, Bg352 and Bg358, respectively during *Yala*. The shortest duration for flowering was observed at *Bombuwela*, *Labuduwa* and *Murunkkan* for Bg300, Bg352 and Bg358 respectively and the longest duration for flowering was observed at *Batticaloa* for Bg300 and *Paranthan* for Bg352 and Bg358 during *Maha*. Higher TT requirement during *Yala* may be due to photoperiod sensitivity of rice. This knowledge of optimal temperature, TT requirements and its seasonal variation is important when designing future physiological and crop modeling studies.

Keywords: Cardinal temperatures, Days to flowering and maturity, Growing season, Rice, Thermal time

RECOVERY OF PHOSPHORUS FROM WASTEWATER BY *Salvinia molesta*.

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One of a major threat to agriculture is the depletion of available phosphorus reserves. Inefficient and irresponsible use of phosphorus fertilizer and other phosphorus based products lead to contamination and qualitative degradation of water bodies. Certain aquatic plants have an ability to sequester phosphorus and thereby purify the eutrophic water bodies. Such aquatic plant biomass can be used as a possible source of phosphorous fertilizer for crops. In this study, the ability of an aquatic plant, *Salvinia molesta* to remove phosphorus from wastewater and recover the absorbed phosphorus through preparing a powdered fertilizer from the dried plants were investigated. A fresh weight of 2005 g of *S. molesta* was introduced into 3 L of 10 mgL⁻¹ of phosphate solution. After 48 hrs of equilibrium time, *S. molesta* resulted 87% of phosphate removal efficiency. The phosphorus recovery process from plant tissue of dried and powdered *S. molesta* remained at 79% from recovery. A hydroponic experiment was conducted to test the growth and yield attributes of rice cultivar Bg 300, in a greenhouse, using a synthetic phosphorus source and *S. molesta* powder as phosphorus sources. The experiment was laid out in a complete randomized design with three treatments and five replicates. Three treatments were viz; T1-Hoagland solution without phosphorus, T2- Hoagland solution, T3- Hoagland solution without phosphorus + *S. molesta* powder. The results indicated no significant differences ($p>0.05$) between early growth of rice plants in both Hoagland solution (T2) and Hoagland solution without phosphorus + *S. molesta* powder (T3). Interestingly, the dry biomass at 28 days after transplanting was similar in both treatments. Hoagland solution and Hoagland solution without phosphorus + *S. molesta* powder resulted significantly higher growth with respect to plants treated with Hoagland solution without phosphorus (T1). This research has generated the first set of data to show the dual ability of *S. molesta* to clean P eutrophied water bodies and to use plant sequestered P as a source of P fertilizer for rice in submerged condition.

Keywords: Phosphorous, Powdered fertilizer, Recovery, Removal efficiency, *Salvinia molesta*

ANTI-MICROBIAL PROPERTIES AND MADE TEA QUALITY OF ORGANIC VS. CONVENTIONAL TEAS OF SRI LANKA

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Ceylon tea with inherently unique characteristics are grown in six major regions in Sri Lanka namely; *Dimbula, Nuwara-eliya, Udapussellawa*, Southern, *Uva* and Kandy under conventional and organic management systems. Organic tea, produced in absence of synthesized chemicals is hypothesised to have better made tea quality and anti-microbial (anti-fungal and anti-bacterial) properties over conventional tea. Present research assessed the effects of tea production system and their growing region on quality parameters, anti-bacterial and anti-fungal properties of made tea. Two tea estates each for organically certified and conventional were randomly selected from each tea growing regions excluding *Nuwara-eliya*. Freshly harvested leaf samples of each estate were manufactured into CTC black tea using a miniature system. Infused tea and tea liquor characteristics were assessed using a sensory evaluation. Anti-bacterial and anti-fungal properties were assessed against disease causing bacteria and fungi namely; *Escherichia coli* ATCC 25922 and *Aspergillus niger* using disk diffusion technique. Aroma and the colour of the infused tea were significant ($p < 0.05$) among growing regions and among the production system, where organic tea showed a greater aroma and a colour. Both production system and growing regions showed a significant difference ($p < 0.05$) on colour, aroma and the overall acceptability of tea liquor. Tea growing regions resulted no effect ($p > 0.05$) on the flavour profile and the liquor strength. Yet, organic tea showed a better flavour profile and liquor strength than conventional tea. Both anti-bacterial and anti-fungal properties were significantly different ($p < 0.05$) among tea production system and the growing region, where organic tea showed higher anti-bacterial and anti-fungal properties than conventional tea. Southern tea had greater anti-bacterial and anti-fungal properties, where it was the lowest in *Uva* region. In conclusion, organic teas have better anti-microbial properties and made tea quality over conventional teas.

Keywords: Anti-bacterial, Anti-fungal, Conventional tea, Organic tea, Tea quality

COMPARISON OF RICE GROWTH AND WEED ABUNDANCE IN ORGANIC, REDUCED AND CONVENTIONAL SYSTEMS: THE FIRST YEAR IN TRANSITION

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Rice (*Oryza sativa* L.) is grown under a wide range of physical environments such as different soils, elevations, hydrological regimes and management systems in Sri Lanka. Although the conventional production practices are widely used in the dry zone, the demand for alternative crop production systems are rising due to economic, environmental and human health concerns. A field trial was conducted at the Rajarata University of Sri Lanka to compare the growth and weed abundance in rice under three input systems; organic, conventional and reduced, during *Maha* season 2018/2019 as the first season of a long-term cropping systems trial. Department of Agriculture (DOA) fertilizer recommendation and 50% of DOA fertilizer recommendation + compost application were respectively used as conventional and reduced systems. The three input systems were arranged in randomized complete block design with three replicates. Results revealed that at seedling and tillering stages, plant height, and plant dry matter were not different ($p>0.05$) among the systems. However, at 50 % flowering stage, plant dry matter was the highest (1464 kg/ha) in conventional system followed by reduced (1222 kg/ha) and organic (1130 kg/ha). At seedling stage, weed density was high ($p<0.05$) in the organic (77%) compared to the other two systems. At 50% flowering stage, no difference was found in weed density among the systems. Weed biomass at 50% flowering stage were high in conventional (56%) compared to organic and reduced ($p>0.05$). Results concluded that organic system at seedling and tillering stages did not show any difference in plant growth compared to the other two systems, but declined at 50% flowering stage indicating a decline in soil fertility. Weed density is high in organic at early growth stages due to inadequate weed control, but weed competition is high in conventional system due high weed biomass growth.

Keywords: Conventional, Crop growth, Organic, Rice, Weed abundance

EVALUATION OF IMAZETHAPYR AGAINST GRASSY WEEDS IN MUNGBEAN

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Weeds are the major biological threat for crop production and due to limited options in controlling, weed emergence simultaneously with crop growth has become a critical in Sri Lanka. Especially in legumes, fast growing weeds suppress the early growth of legume seedlings resulting non-compensatory yield loss. Current regulatory control of glyphosate had opened up avenues for contemporary herbicides. The Imazethapyr 10% Solution (SL) is a newly introduced herbicide for Mungbean in Sri Lanka. This field study evaluated the bio-efficacy and phytotoxicity of Imazethapyr 10% SL against grassy weeds in mungbean. The experiment was conducted during *Maha* cropping season 2018/19 at Research Unit of Faculty of Agriculture, Rajarata University of Sri Lanka. The experiment was laid out on a split plot design with fourteen treatment combinations replicated thrice. Main plot factor was the time of application and sub plot factor was the herbicide concentration. Time of application had two levels aspre-emergence and post-emergence (14 Days After Sowing (DAS)). Herbicide concentrations were Imazethapyr at 50 gha⁻¹, 62.5 gha⁻¹, 75 gha⁻¹, 100 gha⁻¹, 125 gha⁻¹ along with a weed free treatment and an un-weeded treatment. Weed biomass at 20 days after sowing was significantly low in Imazethapyr @ 125 gha⁻¹, however the chemical control always resulted a lower weed biomass than un-weeded control. No significant weed biomass differences ($p>0.05$) were observed between pre-emergence and post-emergence in 20 DAS. Plant biomass at flowering (45 DAS) was significantly ($p<0.05$) high with higher concentration of the Imazethapyr 10% SL. Post-emergence application showed significantly ($p<0.05$) higher plant biomass than pre-emergence application. Grassy weeds were less abundant; however, even with the chemical at higher concentration *Cleome viscosa* and *Cyperus rotundus* were abundant, probably showing their resistant to Imazethapyr 10% SL. Post emergence application of Imazethapyr @ 125 gha⁻¹, 14 (DAS) of Mungbean was found to be effective in controlling most of the grasses and broadleaves.

Key words: Biomass, Herbicide, Imazethapyr 10% SL, Mungbean, Weeds

IMPROVING SOIL CARBON RETENTION USING BENTONITE NANO-CLAY INCLUDED ORGANIC AMENDMENT IN REDDISH BROWN EARTH SOIL IN SRI LANKA

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Soil organic matter plays a key role in soil health through biological, physical and chemical properties. The retention time of soil organic matter is brief in tropics due to rapid mineralisation. General aim of this study was to improve the soil carbon retention by altering the mineralisation rate of common organic amendment; specifically, was to investigate the changes of soil chemical properties and crop performances with the presences of such treated amendment. Reddish brown earth soil was treated with *Gliricidia sepium* leaf and bark to equalise the organic matter content of the soil. Four types of treatments were used viz. organic amendment without additives (T₁), 1% Bentonite (W/W) + Humic acid (100 mgkg⁻¹) organic amendment (T₂) and 2% Bentonite (W/W) + Humic acid (100 mgkg⁻¹) organic amendment (T₃), and an un-amended control (T₀). Maize was the test crop and experiment was laid out on a completely randomized design. The mode of action between Bentonite nano-clay and Humic acid was observed using X-ray Powder Diffraction (XRD), Fourier-Transform Infrared Spectroscopy and Thermal Gravimetric Analysis (TGA). XRD analysis confirmed binding of Humic acid on the surface of Bentonite without intercalation. Differences in the peaks of the TGA graphs were clearly visible due to the modifications of Bentonite by adding Humic acid. The growth and yield parameters of the test crop was significantly ($p < 0.05$) superior on organic amendment with 2% bentonite and Humic acid treated soils compared to the rest. Relative greenness (SPAD values) and plant height were early indicators that showed the efficacy of organic amendment with 2% bentonite and Humic acid in retaining and releasing nutrients for a better crop growth. Bentonite and Humic acid on organic amendments showed promising results in altering the natural mineralization of organic matter under tropical climate.

Keywords: Bentonite, Humic acid, Nano-clay, Organic amendment, Soil organic matter

SCREENING OF MAIZE VARIETIES FOR WATERLOGGING TOLERANCE AT V9 GROWTH STAGE ON MODERATELY DRAINED SOILS

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Cultivation of maize in moderately drained soils during *yala* season in the dry zone is popular among Sri Lankan farmers. However, unexpected heavy rains due to climate change can trigger water logging conditions in these fields at any growth stage of the crop. As maize is less tolerant to water logging, the yield can be severely affected. Therefore, studying the impact of water logging durations on maize growth and yield related attributes is timely relevant. A field experiment was carried out at the Field Crops Research and Development Institute, Mahailuppallama during Maha 2018/2019 cropping season to assess yield response and physiological changes of maize accessions (locally available 30 lines) for water logging conditions at V9 vegetative period (28 days after planting). The experiment was laid out on a split plot design with two replicates. Simulated water logging condition (soil submergence at minimum saturation) was maintained at V9 stage of the crop for 5 days. Initial soil fertility, SPAD reading, leaf length and width, number of leaves per plant, plant height, days to 50% tasseling, days to 50% silking, total biomass and seed yield were recorded. Maize lines, CLYQ 220, CLYQ 203, CLYQ 215, CLRCYQ 49, CLRCYQ 59 and CML 194 were stunted, yellowed and low yielding. Anthesis - Silking Interval (ASI) of selected lines ranged from 1 to 9 days while, ASI of CLYQ 220 and CLYQ 203 extended beyond 10 days. For all maize lines, number of days to tasseling ranged from 55-60 days while silking ranged from 56-65 days. Relative greenness (SPAD values) was depleted after soil submergence in most of maize lines. Multiple cobs were observed in more than 50% maize lines. Elite lines for water logging tolerance are available in locally available maize genome which needs to be explored further.

Keywords: ASI, Maize, Multiple cobs, Soil submergence, Water logging duration

**THERMAL RESPONSE OF LEAF PHOTOSYNTHESIS IN
EVERGREEN TREE SPECIES IN A SECONDARY TROPICAL DRY
FOREST IN CENTRAL SRI LANKA**

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Global temperature has increased by 0.6°C over the past century and is predicted to increase by 1.4–5.8°C by the end of this century. The optimum temperature for leaf photosynthesis ranges between 25°C and 35°C, but predicted increase in temperature may affect light saturated net photosynthetic rate (A_{sat}) and rates of carboxylation capacity (V_{cmax}) and electron transport (J_{max}). Estimation of these rates—largely known for temperate species—enable to model the future changes in net primary productivity of tropical forests. The aim of this study was to compare the optimum temperature of leaf photosynthesis in evergreen tree species against leaf structural traits and shade conditions in a secondary tropical dry forest in central Sri Lanka. The study was conducted in Sam Popham Forest Arboretum, *Dambulla*. Ten leaf structural traits of 10 tree species representing the vertical stratification of the forest were measured from a minimum of three mature tree species. The *in-situ* thermal response of photosynthesis was measured for a range of 20–40°C using a portable infrared gas analyzer by climbing metal towers constructed for canopy access. Contrary to the expectations, leaf shade levels, and structural diversity did not affect the optimum temperature for leaf photosynthesis. The optimum temperature for A_{sat} ranged between 31.05±8.59°C suggesting strong biochemical control over thermal response photosynthesis than the leaf traits measured. Collection and analysis of photosynthetic data from more tropical dry forest tree species is recommended before drawing a solid conclusion.

Keywords: Carboxylation capacity, Leaf structural traits, Optimum temperature for photosynthesis, Rate of electron transport chain

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