



ICDA 2022

8th INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE



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Faculty of Agriculture, University of Jaffna, Sri Lanka.

8th INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE - (ICDA 2022)

“Emerging Appropriate Agro-technologies Towards Food Sustainability”

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(ICDA 2022)**

**“Emerging Appropriate Agro-technologies
Towards Food Sustainability”**

CONFERENCE PROCEEDINGS

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Ariviyal Nagar, Kilinochchi, 44000, Sri Lanka**

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“Emerging Appropriate Agro-technologies Towards Food Sustainability”

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MESSAGES

Message from the Chief Guest & General Chair

JUICE-2022



Prof. S. Srisatkunarahah

Vice-Chancellor

University of Jaffna

Sri Lanka

I'm profoundly glad to be part of this 8th International Conference on Dry Zone Agriculture-2022 hosted by the Faculty of Agriculture University of Jaffna as a satellite conference of the JUICE-2022. On behalf of the University of Jaffna, I cordially welcome scientists, researchers, presenters and attendees to the ICDA-2022. ICDA is a remarkable annual event of the Faculty's calendar to mark the research, development and dissemination of knowledge since its relocation in 2014 in Kilinochchi.

Regional development is the important mission of the University. Agriculture is the prime sector of the Dry Zone of the Sri Lanka. Strengthen the agricultural development is on the shoulder of the Faculty of Agriculture. The ICDA-2022 with the theme of 'Emerging Appropriate Agro-technologies Towards Food Sustainability' is timely needed as the country is severely facing food and economic crises. The ICDA-22 opens a platform to the researchers to share their innovative ideas and appropriate technologies to modernize the Agriculture towards self-sufficient food production.

I believe active participation and fruitful knowledge sharing brings development and all the participants will enjoy informative sessions for sharing views and ideas and developing skills and competencies. I congratulate all staff members of the faculty of Agriculture University of Jaffna for organizing this conference and bless 'ICDA -2022' a great success. All glories to Almighty.

Message from the Conference Chair



Dr. S. Vasantharuba

Dean
Faculty of Agriculture
University of Jaffna
Sri Lanka

I am delighted to welcome you all to the 8th International Conference on Dry Zone Agriculture-2022 hosted by the Faculty of Agriculture University of Jaffna as a satellite conference of the JUICe-2022. It is indeed a privilege and pleasure to deliver this message as the conference chair of the 8th International Conference on Dry Zone Agriculture-2022 which is scheduled to be held on 14th September 2022. ICDA is an annual event in the academic calendar of the faculty and has been a great success in the past seven years. This conference aims to provide an excellent forum to bring researchers from different disciplines to disseminate their research findings, share ideas and experiences on a variety of topics.

The theme of this conference is 'Emerging appropriate agro-technologies towards food sustainability'. Technological advancements are today integral to attaining sustainability goals in agriculture. Nowadays technology innovations have diversified into areas such as indoor vertical farming, modern greenhouse practices, climate-resilient, block-chain, and precision agriculture. Scientific research and advancements in agriculture enable farmers to utilize the technologically smart crop production for nutritious and high yield while minimizing environmental damage, and ensuring food security and cost-effectiveness. With adequate and timely information at hand, even remotely-located rural farmers can adopt climate-resilient and sustainable farming practices that also result in economic gains. This conference provides an opportunity to the researchers to share their emerging and appropriate agriculture technologies towards food security and sustainability in the dry zone of Sri Lanka.

On behalf of the Faculty of Agriculture, I wish to express my sincere gratitude to our Vice-chancellor for his generous support to our faculty. I also wish to thank the keynote speaker, chair of the sessions, presenters, reviewers, sponsors, members of the organizing committee for their support and assistance. Your continuous support helped us to organize this series of ICDA conferences successfully for the 8th year in succession. I sincerely hope these conferences will be organized in the future years also.

I wish the ICDA 2022 would be a great success and contribute immensely towards the development of the dry zone agriculture of the whole country.

Message from the Convener



Dr.K.Pakeerathan

Head and Senior Lecturer

Department of Agricultural Biology

Faculty of Agriculture

University of Jaffna

Sri Lanka

It is my great pleasure to deliver this welcome message as a convener of the prestigious International Conference on Dry Zone Agriculture (ICDA), and warmly welcome you all gathered here to glorify this occasion ICDA-2022 which has been organized with the theme of “Emerging Appropriate Agro-technologies Towards Food Sustainability” as a satellite conference of the JUICe-2022. ICDA is the remarkable annual event of the Faculty of Agriculture which is holding its’ own conference with an abundance of outstanding research papers submitted by both National and International researchers since its inception in 2015. Being the eighth in the series, ICDA’s resounding success has deeply penetrated into the heart of the Agricultural research community around the globe and recognized, therefore, with their support, preside its steady journey in every sense of the term.

Among the many conferences that are being held by quite a number of academic circles, ICDA is very unique because its focus is to disseminate the multifaceted groundbreaking research findings that are most appropriate to dry zone agriculture. Within the economic crisis of the country and the COVID-19 pandemic dilemma, the successful organization of ICDA has required the talents, dedication, and time of many volunteers and strong support from the University administration. Special gratitude and appreciation are due to the physical presence of chief guest and the keynote speaker, and various authors and the reviewers as they are primarily responsible for the content of the technical program.

I would like to acknowledge all the organizing team members, and thank all the delegates in the congregation, students and staff of the Faculty of Agriculture, University of Jaffna, the donors, the contributors, the Chief Guest, and others for your presence and support to ICDA-2022.

The Research and Development on the focused theme are in fast-pace. The technological transformation of the Dry Zone agriculture towards SMART is sudden and path-breaking. Therefore, the ICDA should continue being the standard of the Faculty of Agriculture, University of Jaffna, gaining ground as an entity perpetually with features unique to itself.

Message from the Conference Secretaries



Mrs.A.Kirisan

Lecturer

Department of Agricultural Chemistry

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University of Jaffna

Sri Lanka



Mr.A.Uthayakumar

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University of Jaffna

Sri Lanka

As the joint secretaries of the 8th International Conference of Dry Zone Agriculture, we are delighted and honoured to bring this message.

This year has been a significant year, as we the Faculty of Agriculture, have decided to hold this prestigious conference as a satellite conference of the JUICE 2022. Our theme of "Emerging Appropriate Agro-technologies Towards Food Sustainability" is created to leverage this amazing gathering of professionals to bridge the gaps in agriculture and to connect the gaps in a new and fresh way. This conference will provide some valuable opportunities on top notch research, showcasing innovative research that are utilizing revolutionary technologies. We are transforming the way we operate to continuously improve our ability to meet out the ICDA conference publication standards. Our team of ICDA and reviewers have continued to work rigorously to meet the challenges and to excel despite practical difficulties. We should all be proud of where we are today and excited about the voluntary support of every one associated with ICDA. We would like to thank each of you for attending ICDA 2022 and bringing your expertise to this awesome gathering. With a record number of participants expected this year, we hope that these annual conferences will becoming larger and more substantial every year.

With all your blessings, we hope that the ICDA-2022 will be an unforgettable experience for all the participants.

Good Luck.

KEYNOTE ADDRESS

KEYNOTE ADDRESS

‘Smart Agriculture’ in Japan: an Overview of the Trend



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The application of advanced technologies such as information science to agriculture is a global trend. For example, ‘Agtech’ is being promoted in the United States, ‘Smart Agri’ in the Netherlands, and ‘Smart Farming 4.0’ in Indonesia. In Japan, the movement to actively introduce advanced technologies such as robotics and ICT into agriculture is known as ‘smart agriculture’. The Ministry of Agriculture, Forestry, and Fisheries (MAFF) has taken the lead in this movement, launching a study group in 2013, releasing an interim summary in 2014, and currently budgeting for a variety of demonstration experiments conducted by farmers, universities, local governments, and related companies.

Japan's agricultural sector is facing serious aging problem, and declining competitiveness has become a major issue. One of the challenges is to make agriculture an attractive industry and to create an environment in which bearers can fully demonstrate their motivation and ability, thereby increasing the number of new farmers. Therefore, it is important to reform agricultural technology from the viewpoints of labor-saving, light labor, precision, and information technology. In the fields other than agriculture, the use of robot technology and ICT is progressing, and these technological innovations are leading to enhanced competitiveness, and their use in the agricultural sector is expected to be a powerful driving force for solving various problems and making agriculture a growth industry.

‘Smart agriculture’ initiatives have begun, specifically in the areas of 1) robotics, 2) big data, 3) artificial intelligence, and 4) IoT. For example, 1) robot technology can be

applied to powered suits and automated tractors; 2) big data can be used for efficient cultivation management by utilizing data from fields measured by sensors; 3) artificial intelligence can be applied to systematize superior technology and know-how, making it easier for new farmers to engage in farming; and 4) IoT can be used to grasp the needs of markets and consumers and to provide them with the tools they need.

More than five years have already passed since its inception, and ‘smart agriculture demonstration projects’ aimed at social implementation have been promoted in various parts of Japan since 2019. As a result, while there are positive aspects of ‘smart agriculture’, the issues that need to be addressed in order to promote its widespread use is becoming clear. The general problems include the high cost of advanced equipment, the fact that the technology of skilled farmers cannot be applied by everyone, and the workability and operability of the equipment. Improvements are expected from both the development and utilization sides.

Furthermore, MAFF has launched a project called the ‘Agriculture DX Concept,’ which has an idea of ‘Farming as a Service (FaaS)’ that aims to create and provide value that more accurately meets consumer needs under the concept of data-driven agricultural management starting in 2020. This project aims to revitalize agriculture in the context of digital transformation, and is an evolution of the ‘smart agriculture’ policy in that it incorporates the perspective of consumer needs.

Meanwhile, Japan's international cooperation is also incorporating ‘smart agriculture’ and ‘agricultural DX’ technologies and skills. Japan International Cooperation Agency (JICA) is trying to promote DX through technical cooperation, human resource development, private-sector collaboration, and financial cooperation schemes in a wide range of fields. The term they use in agriculture and rural development is ‘Smart Food Chain’, where the entire food chain process from breeding, production, processing/distribution to consumption will be made smarter using AI and data integration platforms to improve productivity, eliminate waste, reduce total costs, add value to crops and food products, and match needs and seeds.

Universities are often involved in these developments. Universities are the places where innovation is generated and leading human resources are incubated. Research and education, the core roles of universities, will be increasingly required. Looking back, when I was a graduate student, I used to set up spontaneous "study groups" to learn more about new theories or specific issues. This took the form of students, and young faculty members taking the lead in introducing a certain textbook or article and engaging in free discussion. It was not a credit given class, and was set up on Saturdays and Sundays, or in the evening, regardless of the availability of the professors. These units transcend the boundaries of a laboratory, faculty or single university. The members come together around a common interest, becoming the future body for joint research. I hope the voluntary occurrence of such study groups on various topics with free talks may contribute the progress of research.

ABSTRACTS OF THE PROCEEDINGS

Designing Packages of Practice to Increase Home Garden Crop Production in Sri Lanka

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Significant interruptions in the food supply system caused by the novel COVID-19 pandemic have worsened the severe problems of malnutrition and nutritional deficiency. As a lesson learnt from such crises, home gardening is a cost-effective option to handle food and nutritional insecurity and supply sufficient food for the growing population. Nevertheless, all gardeners are not farmers, and the lack of an easy mechanism to find gardening instructions causes beginners to do away from gardening. Therefore, a study was conducted to provide useful information *via* a mobile app named “*Govi-Nena*” (for Android and iOS platforms). The design science research (DSR) approach was used to develop packages of practice (PoP) workbooks for home garden crops. The DSR methodology consists of 3 basic cycles; Relevance, Rigor and Design. The study was started with the rigor cycle and gathered information from reliable and publicly available sources to create initial artefacts. Additional requirements were collected from domain experts in the application domain of the relevance cycle. The PoP workbooks have been verified and validated by experts during a number of field visits and enhanced the artefact in the design cycle. In order to test the PoP knowledge satisfaction on a 5-point Likert scale method, a pre-tested Google form-based questionnaire was distributed among 32 *Govi-Nena* mobile app users and analyzed using Wilcoxon one sample signed-rank test. All users were delighted ($p < 0.05$) with the information provided in the app, especially agro-climatic zone-based crop variety selection, choosing fertilizer types, amount, quality, accuracy and user-friendliness of information, and other pre-planting, growing and harvesting practices. Obviously, this potentially useful tool provides context-specific, complete, and actionable information through the convenient app that assists home gardeners in making informed decisions on crop production, eventually support to meet the growing demand for food security in the country.

Keywords: Design Science Research, Food security, *Govi-Nena*, Packages of practice

Impact of Different Seedlings Age on Growth and Yield of Machine Transplanted Rice (*Oryza sativa* L.)

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Transplanting rice seedlings by Rice machine transplanter is one of the labour-saving technology in rice establishments. In mechanically transplanted rice, delayed transplantation is common practice, resulting in a significant reduction in grain yield. As a result, determining measures to compensate for the grain production loss is crucial for rice cultivation technology improvement. A field experiment was conducted to investigate the impact of different seedlings age on the growth and yield of machine transplanted rice at Rice Research Station, Paranthan, during 2017/18 *Maha*. Rice variety of *Bg406* was transplanted with 8, 10, 12, 14, 16, 18, 20, and 22 days-old seedlings by machine transplanter with a plot size of 4.5 m x 5.7m under RCBD design with four replicates. The plant height, tiller density, leaf area index, panicle density, panicle length, the weight of 1000 grains and grain yield were obtained and statistically analyzed through ANOVA and means separation was done by Duncan's Multiple Range test at the 5 % probability level. Results revealed that the transplanting of sixteen days old seedlings recorded the highest number of tillers significantly at harvest (281.25 m⁻²), leaf area index (3.663 m⁻²), and the number of panicles at harvest (242.25 m⁻²), and grain yield (5.065 t/ha). This study concluded that a plant seedling age of sixteen day-olds could be considered the optimum planting age for machine transplanted rice crops for the variety of *Bg406* in the Northern region.

Keywords: Growth, Machine Transplanter, Rice, Seedling Age and Yield.

Phyto-Toxicity of Herbicide; Benzobicyclon 280gl–1 SC on Rice

***Bandara¹, R.M.U.S., Wickrama¹, W.M.U.B., De Silva¹, Y.M.S.H.I.U., Dissanayaka¹
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Benzobicyclon 280 gl⁻¹ SC is a broad spectrum pre- to early post-emergent herbicide used in direct-seeded and transplanted rice. This is very effective against annual and perennial weeds. It has a long residual activity in soil (60 days). It kills weeds by inhibiting 4-hydroxyphenyl pyruvate di-oxygenase (4-HPPD) enzyme. Phyto-toxicity of *Benzobicyclon280gl⁻¹ SC* can be seen as chlorosis and bleaching of leaves. Phyto-toxicity of *Benzobicyclon280gl⁻¹ SC* on 10 commonly grown rice varieties (*Bg250*, *Bg251*, *Bg252*, *Bg300*, *Bg310*, *Bg352*, *Bg358*, *Bg366*, *Bg374* and *Bg360*) was studied at the Rice Research and Development Institute, Batalagoda during *Yala* 2018. The objective of the study was to determine the severity of the herbicide injury by *Benzobicyclon280gl–1 SC* in commonly grown rice varieties in the dry zone and intermediate zone of Sri Lanka and to determine the possibility of using the herbicide, with minimum crop injuries. *Benzobicyclon280gl⁻¹ SC* was applied at the rates of 200, 300 and 600 g (a.i.) per ha at 07 days after sowing of paddy. Herbicide injury severity % was recorded two weeks after herbicide treatments according to Standard Evaluation System of Rice introduced by International Rice Research Institute. Data were subjected to ANOVA using SAS 9.0 software package. Results revealed that *Bg250*, *Bg251*, *Bg300* and *Bg310* showed no herbicide injuries under the tested dosages. *Bg252*, *Bg352*, *Bg358*, *Bg366*, *Bg374* and *Bg360* showed significantly higher herbicide injury severity % in all three tested dosages than other varieties ($p < 0.05$). Therefore, as phyto-toxic effect of *Benzobicyclon280gl⁻¹ SC* differs with the variety, variety-specific recommendations based on further studies with different varieties are required instead of a general recommendation of BSC for paddy cultivation in Sri Lanka.

Keywords: Benzobicyclon, Herbicide injury, Broad spectrum herbicide, Pre-emergent, Early post-emergent

Yield Performance of Traditional Rice Varieties at Rice Research Station, Murunkan

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Government of Sri Lanka is attempting to re-introduce traditional rice to farmer fields as a component of organic rice production, mainly due to its nutritive and ayurvedic value and resistance to biotic and abiotic stresses. In order to expand the organic paddy cultivation and utilize the data for future breeding program to harness the medicinal value of these traditional varieties, this study explored the agronomic performances of traditional varieties at the rice research station in Murunkan. The study was conducted during 2020/2021 *Maha* season. There were fourteen Sri Lankan traditional rice cultivars were used for the experiment. The experiment was conducted in a randomized complete block design with three replicates. Fifteen plants from each cultivar were evaluated for the selected characters namely, plant height, leaf blade length, leaf blade width, number of tillers, number of reproductive tillers, panicle length, number of spikelets per panicle, number of fertile spikelets per panicle, seed length, seed width, seed weight and grain yield were recorded. Recommended modern rice cultivar *Bg360* was used as the reference variety. The average plant height of the tallest rice cultivar, Malkorathu was 140.14 cm and that of the shortest rice cultivar, Kalundai was 88.68 cm. The longest leaf blade was also belonged to Malkorathu. The highest number of tillers (8 tillers per plant) was recorded to Pachchaperumaal and the highest average number of reproductive tillers (6.7 per plant), was recorded for rice cultivar Kalundai. The highest value of 500 seed weight was recorded for rice cultivar Anilvariyan which was 26.63g. The reference *Bg360* variety (5.8 t/ha) gave significantly highest yield than the tested traditional varieties. The purpose of the study was to evaluate the performance of agronomic characters of landraces in developing new varieties that are adaptable to climate change and suitable for organic cultivation. The average yield of Beheth heenati, Pusparaga, Madathawalu, Rathkayan, Mottaikaruppan, Anilvariyan Weda heenati, Suwandal, Kadanvi, Rathu heenati, Pachchaperumal, Malkorathu, Beheth heenati rathu and Kalundai were 4.21, 4.20, 3.98, 3.75, 3.63, 3.58, 3.56, 3.5, 3.23, 3.21, 3.19, 3.10, 2.48 and 2.34 t/ha, respectively.

Keywords: Ayurvedic value, Spikelets, Tillers, Traditional rice varieties

Effect of Phytohormones in Mitigating Terminal Heat Stress and Enhancing Seed Yield in Maize Hybrid COH (M) 8

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Maize is one of the leading crops in the world and is widely cultivated as a cereal grain. Heat stress is a main threat to current and future global maize production. Maize plants are sensitive to terminal heat stress and there is a strong decline in grain yield as plants face heat stress above the threshold level for a prolonged duration. Adaptation of maize to future warmer conditions requires improving our understanding of crop responses to elevated temperatures. Terminal heat stress negatively affects maize yield during the maize growing season. The present study was conducted in the high temperature zone at ARS, Bhavanisagar, Tamil Nadu, India with an aim of exposing the plants to high temperature during the flowering period to evaluate the influence of phytohormones on mitigating heat stress and improving pollen viability, seed set and seed yield of maize. These studies were carried out in the maize seeds COH(M) 8 for identifying the suitable phytohormone for alleviating terminal heat stress. The crop was foliar sprayed with various phytohormones such as salicylic acid @ 50 and 75 ppm, brassinolides @ 0.2 and 0.5 ppm and sodium nitroprusside @ 50 and 75 μ M at 40 and 47 days after sowing compared with control (No spray). The experimental trial was carried out with Randomized block design in three replications. The observations on seed yield attributes were recorded in ten randomly selected plants of each treatment. The significance of data was determined using the "F" test. critical differences (CD) were computed at a 5% probability level. The results of the study revealed that the maize crop foliar sprayed with sodium nitroprusside 50 μ M at 40 and 47 days after sowing improved the pollen viability and yield attributes viz., number of seeds/cob, 1000 seed weight and seed yield/ ha (kg) of maize under high temperature conditions when compared to control and other treatments. The foliar application of phytohormones induces high temperature stress tolerance in maize plants and could help the plants cope with terminal heat stress by scavenging reactive oxygen species, upregulation of antioxidant enzymes and protection of cellular membranes thus resulting in higher seed yield.

Keywords: Maize, Terminal heat stress, Phytohormones, Pollen viability, Seed yield.

Evaluation of Organic Inputs in Cinnamon (*Cinnamomum zeylanicum* Blume) Nursery Media along with Subsoil as Alternative Potting Mixture

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True cinnamon comes from *Cinnamomum zeylanicum* Blume family Lauraceae is one of the oldest tree species indigenous to Sri Lanka. The objective of this research was to investigate the effect of various alternative potting mixtures on the growth of cinnamon seedlings. Half burnt paddy husk, Concentric Microbial Solution (CMS) and gliricidia solution were the selected organic substances which used for the potting mixture along with the subsoil. Treatments comprised two levels of Half Burnt Paddy Husk (availability and non-availability), four levels of CMS (0%, 4%, 10%, 20%) and two levels of gliricidia solution (availability and non-availability). The experimental design was split-split plot design with four replications. Half Burnt Paddy Husk was in the main plots, levels of CMS in the sub-plots and gliricidia solution in the sub-sub plots. All together there were 16 treatment combinations and control plot was prepared using Department of Export Agriculture recommended potting mixture coir dust: top soil: cow dung: sand (1:1:1:1). Results indicated that the availability of half burnt paddy husk in the nursery media significantly enhances the seedlings' height and total root length by about 7% and 22%, respectively. The highest concentration of CMS significantly enhances the total root length by about 32%. Significantly highest microbial activity was detected in the highest concentration of CMS. But when compared to the control, all the treatments were showed poor vegetative growth, soil chemical and biological properties. It can be concluded that the availability of half burnt paddy husk and the highest concentration of CMS significantly enhanced seedling's vegetative growth while CMS enhanced the soil's biological properties.

Keywords: Bio-fertilizer, Gliricidia, Half Burnt Paddy Husk, Microbial Activity

Formulation and Quality Evaluation of a Healthy Cereal Bar with Traditional Rice (*Oryza sativa*) *Suwandel* and *Pachchaperumal*

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The demand for ready-to-eat foods, such as cereal bars is increasing rapidly among consumers due to their availability, affordability and convenience. This study focused on development of a nutritious Cereal bar using *Suwandel* rice flour and *Pachchaperumal* rice popcorn as alternative to high sugar snacks. The novel recipe was developed from a compressed mixture of rice, coconut and honey, varying proportions of *Suwandel* rice and *Pachchaperumal* rice popcorn were combined with other ingredients and subjected to sensory evaluation and statistical analysis. The combination of 90% (w/w) *Suwandel* rice flour and 10% *Pachchaperumal* rice popcorn (T3) obtained the highest overall acceptability compared with other samples and T3 was selected as the best formulation. Physico-chemical properties, proximate analysis and shelf life evaluation were conducted for T3 and compared against the control sample. Crude protein, crude ash and crude fibre level of the new product were higher (14.75%, 2.54% and 6.79%) compared to those of the control (12.46%, 1.71% and 5.81%) respectively. New product had 4.15% crude fat and 64.65% carbohydrate content which were significantly lower than the control sample with 4.24% crude fat and 67.83% carbohydrate. After 5 days of storage period, moisture content has increased to 7.12% in new sample and 7.95% in control sample which indicates that new product has comparatively longer shelf life. According to the results, new cereal bar with traditional rice has gained better attributes. Hence it can be promoted as a value added healthy food product while enhancing the utilization of traditional rice varieties.

Keywords: Cereal bar, Nutrition, Snack foods, Traditional rice, Value added

Development and Quality Evaluation of Gluten-Free Baby Rusk using *Madathawalu* rice (*Oryza sativa* L.) and Mung bean (*Vigna radiata*) Composite flour

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Rusks are widely consumed baby snacks that are commonly produced using wheat flour. Wheat flour was reported to cause health issues due to gluten. This study aimed to produce a nutritious, gluten-free baby rusk using a local grain flour composite made out of a traditional rice variety (*Madathawalu* rice) and mung bean to eliminate the health hazards. The sensory attributes, physical properties, and proximate compositions of the novel composite rusks were evaluated and compared with baby rusks made with wheat flour as the control. The combination of 70% *Madathawalu* rice and 30% Mung bean (T2) resulted in the highest sensory attributes and was selected as the accepted formulation. The best sample was further analyzed for physical properties, proximate analysis, and shelf-life evaluation. The new formulation reported a relatively lower diameter (52.41 mm) and spread ratio (9.26 mm) while it had a higher weight (12.22 g) and thickness (5.67 mm) compared to the control (55.37 mm, 11.44 mm, 10.22 g, and 4.85 mm correspondingly). The traditional rice and mung bean-based new formulation (T2) demonstrated a darker color due to the nature of its main ingredients. Rusks from T2 had higher protein (17.03%), crude fiber (2.50%), and ash (2.23%) contents compared to the corresponding levels of 11.68%, 1.65%, and 1.44%, in the control sample. The new rusk formulation demonstrated significantly lower crude fat (15.10%) content than the control (19.57%). Moisture levels have increased to 4.12% in new flour composite rusk and to 5.89% in the control after 21 days of storage. Based on the moisture content, the new rusk has indicated a comparatively longer shelf life. The new rusk could be commercialized as a nutritious and gluten-free product and it may create a competitive opportunity in the baby food market.

Keywords: Baby rusk, Food allergy, *Madathawalu* rice, Mung bean

Variation in Colour Attributes of Arrowroot (*Maranta arundinacea*) Flour from Five Different Provinces in Sri Lanka

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In Sri Lanka, Arrowroot (*Maranta arundinacea*) is an underutilized tuber crop with tremendous potential for producing gluten-free, nutritious flour that could be used as a wheat flour substitute. This study aimed to evaluate the colour attributes of Arrowroot flour from five different Provinces in Sri Lanka to determine whether the growing area had an impact on the colour of the flour. From Western, North-Western, Southern, Uva, and Sabaragamuwa Provinces three locations were selected for sampling since they have favourable climatic conditions for growing Arrowroot. The colour parameters L* (lightness), a* (redness), and b* (yellowness) were measured using a Colourimeter (PCE-CSM 2, United States). The lightness of the flour samples was found to be significantly different from one another. The a* values for flour samples collected from five Provinces did not differ significantly. The mean a* values ranged from 1.07 to 1.40. The b* results for Arrowroot flour samples from five different Provinces had a range of 6.85 – 8.69. The Province with the highest b* was Sabaragamuwa, while the Province with the lowest was Southern (6.85). The overall L*a*b* colour coordinates of Arrowroot flour samples from five Provinces coordinated around the white colour with minor positive values for red and yellow colours. L* and a* (-0.75; $p < 0.05$) and L* and b* (-0.788; $p < 0.05$) had negative moderate correlations, indicating that when the a* and b* values increase, the flour sample's lightness decreases. Arrowroot flour has a higher level of colour similarity, indicating that the growing area has a lesser influence on the colour of flours. The similar colour attributes of flours from different growing areas in Sri Lanka enable the use of composite flours from different places without significant colour variations. It is beneficial in the large scale Arrowroot flour production for the food industry.

Keywords: Arrowroot, Flour colour, L*a*b* values, lightness, *Maranta arundinacea*

Production of Cashew Apple (*Anacardium occidentale* L.) Flour and Determination of its Physicochemical, Functional and Nutritional Properties

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Cashew is an important cash crop in Sri Lanka which is being cultivated, especially in the dry zone of the country. Although cashew nuts have a high demand in both local and export markets, cashew apple is a highly underutilized fruit due to its extreme perishability and lack of awareness of processing technologies. This study aimed to develop an appropriate method to produce cashew apple flour and to determine the physical and functional properties of the flours resulting from different methods. The cashew variety WUCC-05 was used, and three methods were applied for the flour preparation, namely, oven drying of raw cashew apple (Method 1), boiling followed by oven drying (Method 2) and hydro blanching followed by oven drying (Method 3). Then, flour density, water absorption capacity (WAC), oil absorption capacity (OAC), swelling power (SP), water solubility index (WSI), flour colour, pH and proximate compositions were analysed. Method 2 was the best method for cashew apple flour preparation, as it resulted in desirable physical and functional properties, such as high bulk density (0.67), high WAC (274.60%), and high SP (8.95 g). Moreover, the proximate composition of the flour resulting from Method 2 revealed its ash (2.24%), crude fiber (4.54%), carbohydrate (72.12%), crude fat (4.31%) and crude protein (9.08%) contents. The moisture contents of the flours resulting from the three methods were within the acceptable limits (<10%). Collectively this study revealed that cashew apple flour has potential applications in bakery industry and can be promoted for value-added product development due to its desirable qualities.

Keywords: *Anacardium occidentale*, Cashew apple flour, Physical properties, Proximate composition

Effect of Malting Duration on Proximate Composition, Total Phenolic Content and Total Flavonoid Content of Pearl Millets Grown in Sri Lanka

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Pearl millet (*Pennisetum glaucum*) is one of the promising under-utilized crops in Sri Lanka. Because of its prospective nutritional composition and health benefits, it could be used to develop healthy food. Malting can increase the nutritional value of Pearl millet by increasing its induced hydrolytic activity. Therefore, this study aimed to investigate the effect of malting duration on the proximate composition of Pearl millets grown in Sri Lanka. Initially, Pearl millet (600g) was steeped in 1.2 L of water in a stainless-steel bowl for 24 hours at room temperature (28 °C) in triplicates. To prevent fermentation, the water in the bowl was replaced every 6 h with fresh water. Finally, the water was drained and grains were spread as thin layer over a moist muslin cloth for germination for different durations as treatments (12, 24, and 48 h). The germinated grain was sun-dried for 3 days, manually cleaned to remove the husk, and the malted grains were ground and sieved to obtain the flour. The samples were analyzed for moisture, protein, carbohydrate, fat, ash and fiber contents and total phenolic (TPC) and total flavonoid (TFC) contents. Pearl millets malted for 24 h contained significantly higher ($p \leq 0.05$) amounts fiber ($2.654 \pm 0.46\%$) than the raw Pearl millet ($0.925 \pm 0.13\%$). Pearl millets malted for 48 h contained significantly higher ($p \leq 0.05$) moisture ($12.025 \pm 0.01\%$) and crude protein ($8.495 \pm 0.02\%$) than from the raw pearl millet ($8.025 \pm 0.01\%$ and $7.115 \pm 0.22\%$ respectively, whereas, carbohydrate and fat contents decreased significantly ($p \leq 0.05$) from $78.69 \pm 0.19\%$ and $4.69 \pm 0.18\%$ to $75.615 \pm 0.02\%$ and $0.05 \pm 0.005\%$, respectively after 48 h of malting. There were no significant changes ($p \leq 0.05$) in the carbohydrate and protein contents with duration of malting. Crude fat and crude fiber contents did not show significant differences ($p \leq 0.05$) between 24 h and 48 h of malting. The significant reduction ($p \leq 0.05$) in TPC from 0.5435 ± 0.042 mg gallic acid equivalent/100g to 0.1635 ± 0.040 mg gallic acid equivalent/100g was reported after 48 h of malting, whereas the TFC was increased significantly ($p \leq 0.05$) with highest value (0.062 ± 0.003 catechin equivalent mg/100g) reported at 24h of malting. The findings of this study demonstrated that malting for 24 h could be employed as a processing technique to improve the nutritional value of pearl millets-based foods.

Keywords: Flour, Pearl millets, Malting, Healthy foods.

Investigation of Soluble Impurities in Sugar Juice Manufacturing Process

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Dust particles, mud and sand particles, dead and live animals, and dry plant biomass had been reported in initial stage of crushing sugar cane. The major goal of this work is to investigate the percentage of soluble mud, sand, dust, biomass, and other contaminants in the sugar juice used to make brown sugar. Further investigations were done to find out percentage of juice loss with bagasse and mud filter cake. During the milling of sugarcane, extraneous contaminants are mixed with sugar juice. Those extraneous contaminants were impact the sugar quality. Brix value (percent soluble solids) was measured on a Brix meter at 20 °C of sugar juice before and after remove the soluble impurities and to remove soluble impurities, juice was filtered through filter paper applying lead acetate as a catalyst to solidification of soluble impurities in sugar juice. Juices extracted from various stages of the sugar making process were used to determine the impurities percentage of sugar juice. Findings are showing that, first mill juice (juice extracted from first mill), last mill juice (extracted juice from last mill), mixed juices (after mixing juices extracted from all mills together), clarified juices (after clarification process) and final product (sugar) average impurities percentages are 16%, 22%, 16%, 15% and 3% respectively. The polarization (Pol) value of bagasse (residue left after the extraction of juice from sugar cane) and mud filter cake (remove mud from clarification process) was measured on a polarimeter. As a result, was determined average percentage of the sucrose loss with bagasse and mud filter cake are 2.01% and 2.21% respectively. A conclusion could draw the presence of impurities in the juice extracted after the milling of sugar canes and the presence of a significant percentage of impurities in the juice even after the clarification stage. As well the final product sugar also contains a significant percentage of impurities, and it is affected quality of sugar. The amount of sucrose loss with bagasse and mud filter cake has a limitation rated value 2% and compare with result, sucrose loss with bagasse and mud filter cake exceeded rated value. The sucrose loss directly affects to decrease the productivity. As stated above, the outcome demonstrated that main reason of decrease sugar quality, soluble impurities were directly impacted and in clarification process soluble impurities was removed difficult. Another finding indicated that there was sucrose loss when bagasse and mud filters were removed. Therefore, could be removed impurities before milling the sugarcane to increase the quality of the final product and decrease sucrose loss.

Keywords: Bagasse, Brix value, POL value, Soluble impurities, Sugarcane

Knowledge, Attitude and Behavior of Consumers on Food Safety in Sri Lanka

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Food safety is very crucial in among the particular group of people. Poor eating habits are a major concern among university students. Prime objective of this research was to assess knowledge, attitude and behavior on food safety among the consumers in Sri Lanka. As the method of the research, descriptive cross sectional community based study was adopted. For the sampling it was obtain from density of the population of each district in Sri Lanka. Simple random sampling technique was employed to the study as in every district 5% of samples were collected from persons per square kilometer of each district. Samples (n = 576) were collected from each district in the Sri Lanka for the fulfillment of the survey. Finally 608 of samples were collected including 32 of volunteer people. Data were approached from person with a print version of the survey or an electronic link (Google form). A self-administered questionnaire was use consumer in this study. The Statistical Package (SPSS 20) was used for analyze the data on demographic, knowledge and attitude on food Safety parts. Through descriptive, socio-demographic and knowledge of the participants were described and expressed as frequencies. As the correlations the nutritional knowledge had significant relationship ($p < 0.05$) and ($p < 0.01$) as variables. According to the research hypothesis consumer knowledge, attitude and behavior on food safety differ with the gender, educational level and the occupational variables. However, geographical background of the respondents was not differing with the consumer knowledge, attitude and behavior on food safety. Behavior and food handling practices are very poor in Sri Lankan people. Therefore, the study concluded that knowledge, attitude and behavior on food safety of consumer are a critical factor that requires close attention.

Keywords: Consumer preferences, Eating habits, Food hygiene, Food safety.

Virtual Water Trade of Indian Maize for Global Food Sustainability

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Water is the renewable resource and its availability varies with time and space. Agriculture is the one sector which is consuming enormous amount of water for production. The hidden or embodied form of water in the commodity is known as virtual water. The international trade of commodities indirectly shows the transfer of water across countries in virtual form. Virtual water trade is an emerging phenomenon which helps in determining country dependency or self-sufficiency on water resources with other countries. The inefficient application of water resources has become an urgent problem restricting the world's sustainable development. The current study aims in determining the virtual water trade in maize crop and crop products of India. Maize is the multipurpose crop as it used as food, feed and as raw material for industries. It is highly demanded as feed by cattle and poultry sector as it supplements high protein content in diet. Poultry and cattle accounts 63 percent of maize consumption whereas human maize consumption is only 8 percent. The results of the study indicates that India is the net virtual water exporter of maize crop and crop products. The average water usage associated with Indian Maize production is 56901 Mm³. The major virtual water flow is diverted to Bangladesh, Nepal, Vietnam and Malaysia. The highest virtual water content exported is 6648 Mm³ in the year 2020-21 and highest virtual water content imported is 898.24 Mm³ in the year 2019-20. Virtual Water Balance for maize in India is negative because the volume of virtual water import is less than virtual water export. Even in situation of negative virtual water balance, the virtual water flow of maize is increasing in recent years which indirectly contributes in achieving the global food sustainability of importing nations.

Keywords: Global Food Sustainability, Indian Maize, Virtual Water Trade

Potential and Pitfalls of Moringa Value Chain in the Dry Zone of Sri Lanka

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Although *Moringa oleifera* is identified as a nutrient-dense, superfood with an increasing demand in the international market, it is a disregarded plant in Sri Lanka with vast potential to tap into the international market while improving rural income. Thus, this study attempts to identify the existing potential of the plant to act as an income generator in the rural community. Value chain analysis was done to map the existing value chain for both *M. oleifera* leaf and pod-based products and identify main and enabling actors, channels and constraints along both value chains. Value addition and gross profit margins were calculated along the value chain in order to identify the profit margins gained by each actor for the value they add throughout the process. Farmers were selected from the dry and intermediate ecological zones where most of the cultivation takes place. A total of 47 participants were drawn purposively, and interviewed through face-to-face interviews and telephone conversations using open-ended semi-structured questionnaires, in order to gather the primary data needed. Findings show that the *M. oleifera* leaf value chain is complex than the pod-based value chain, with 08 major channels, while the pod-based chain consists of only 05 channels. Exporters add the highest value in both value chains. It is concluded that *M. oleifera* leaf farming can be identified as advantageous cultivation in rural communities as leaf farmers gain a considerable amount of profit margin. Even though there is a high potential and return for *M. oleifera* based products, the communication gap among actors in the value chain and lack of awareness among local consumers hinder the possible income generation along the value chain.

Keywords: Actors, Mapping, Moringa, Value addition, Value chain

Trade of Virtual Water in the Context of Food Sustainability – A Particular Reference to Pulse Import in India

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The present study aimed to assess the Virtual Water Import of Lentil and Bengal gram in India. The growing water concerns led to the development of new concepts like 'Virtual Water'. Pulses, supplemented with cereals, provide a perfect mix of vegetarian protein and an important source of food sustainability. Sustainable food contributes to four pillars of food security: availability, access, utilization and stability. The availability of pulse is less in India due to meagre production, but the utilization is high and met through import. The productivity of pulses in India is less than half of the productivity levels in the USA and Canada. Lentil import is high among pulse, i.e., 5.6 lakh tonnes. Even though India is the second largest producer of Lentil, the consumption exceeds production and is therefore supported by imports. Canada is the largest supplier of Lentil because it leads in production, where 95 per cent is produced in the province of Saskatchewan. Virtual Water Trade had been calculated using virtual water content and quantity of import resulted the specific water demand is 1.47 kg mm^{-1} , and the average yield is 1238 kg/ha . India also imports chana despite being the largest producer and having high consumption requirements. The specific water demand for chana is 1.79 kg mm^{-1} , and the yield is 1547 kg ha^{-1} . This study shows that the average virtual water import for India during 2007-2021 in the case of Lentil is 1.03 billion m^3/year , and for Bengal gram, it is 9.8 million m^3/year . Since the third world war is predicted to occur because of water crisis the import from countries with less water requirement for producing pulse is recommended. India by importing Lentil and Bengal gram instead of producing it domestically, it saves about 2370 and 1790 cubic metres of real indigenous water, respectively. This water can be used for production of other agricultural commodities in India.

Keywords: Food sustainability, Indian pulse, Specific water demand, Virtual water import.

A Quantification of Virtual Water Trade of Major Agricultural Commodities in India

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This paper provides the economics of Virtual Water (VW) exporting to other countries through major agricultural commodities from India. VW is interconnected with food sustainability and it is the amount of hidden water transferred to other countries through trade. India produces and exports high water-consuming products but contains only 2.56 % of total water available in the world. By analyzing VW, the comparative advantage in producing the commodity in India can be obtained. VW for major crops was estimated by dividing the total water required or applied for the specified crop by the total yield of the crop. In this paper, Virtual Water Trade (VWT) was computed for the major crops in India and analyzed the comparative advantage for India in producing the crop. The data required for the analysis were collected from various secondary sources such as the Directorate of Economics and Statistics (DES, GoI), Indian Agricultural Statistical Research Institute (IASRI), EXIM Bank, and FAO Aqua Stat. In the years 2018-19 and 2017-18, India exported 34515 MCM and 41080 MCM of VW through rice followed by 420 MCM and 622 MCM of VW through wheat, 276 MCM and 184 MCM of VW through maize. When comparing the production of rice and groundnut in China and India in water requirement aspect, India has the comparative advantage in the production of groundnut and China has the comparative advantage in the production of rice and also showed the same in the yield aspect. With the growing water scarcity in India, we should shift the focus from the high water requirement crop to the lower crop to sort out the water scarcity problem and attain sustainability.

Keywords: Comparative Advantage, Sustainability, Virtual Water Trade, Water Scarcity.

Cost Benefit Comparison for Different Compost Manufacturer Categories in Sri Lanka

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An ad-hoc decision to ban inorganic fertilizer created a massive and irreversible crisis due to the scarcity of fertilizer. Even though organic fertilizer is a good substitute for inorganic fertilizers, organic fertilizer production is limited and inadequate supply is seen in the market. Compost is a major type of organic fertilizer. This study aims to study the organic fertilizer industry in Sri Lanka in order to identify its constraints, possibilities and prospects, focusing on compost production. Financial constraint is the major constraint for the compost production process. The economic profitability of the compost fertilizer production process was evaluated in small (ten producers), medium (eight producers), and large-scale compost producers (four producers) using the cost-benefit analysis method. Four indicators were calculated: Net Present Value (NPV), Internal Rate of Return (IRR), Pay Back Period (PBP) and Benefit Cost Ratio (BCR). The analysis was carried out utilizing primary data collected through face-to-face interviews with compost producers. Sensitivity analysis was conducted considering different discount rates. The small-scale producers' NPV was Rs.217,537.70, IRR was 10.7%, PBP was 7.97 months, and BCR was 1.41. The medium-scale producers' NPV was Rs.2,418,521.17, IRR was 26.0%, PBP was 3.65 months, and BCR was 1.59. The large-scale producers' NPV was Rs.10,921,816.06, IRR was 60.8%, PBP was 1.64 months, and BCR was 1.45. Accordingly, the large-scale compost producers carry out the most profitable production in terms of financial aspects. Large-scale producers allocated a higher portion of the cost for raw materials, while medium and small-scale producers spent higher for establishment and machinery. It is also clear from the results that the IRR value is higher than the bank interest rate for each compost manufacturer category, and each scale of compost manufacturers can take a viable credit facility to start a compost manufacturing process.

Keywords: Compost Fertilizer Production, Cost Benefit Analysis, Net Present Value

Cost and Benefits of Climate Resilient Livestock Production in Tropics: A Conceptual Analysis for Adaptation Techniques

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Climate change impacts are of serious concern in livestock production all over the world. Scientists have come up with several adaptation techniques to apply for climate resilient livestock production. The livestock farming requires adjustments in economic and social systems to adapt to climate change and its impacts for its sustainability. The climate resilient livestock production techniques that incur cost and the consequent benefits are found limited in previous studies compared to crop production. Hence this study was carried out to propose a conceptual model integrating cost incurring adaptation techniques and subsequent benefits which will be helpful to analyze the economics of livestock production under climate change in tropics. A detailed literature review was carried out to identify the potential cost incurring adaptation techniques for livestock production to thrive under climate change and their benefits. According to the literature reviewed, major cost incurring adaptation techniques were identified as adaptation to heat-stress, mitigation measures applied for drought tolerance and variable precipitation, adaptation against pests and diseases and adaptation for change in pasture and fodder production. The consequent benefits of the implementation of the adaptation techniques were identified as higher level of productivity under heat-stress, increased water use efficiency, improved animal welfare, and increase in pasture and fodder availability. From the conceptual analysis, it is concluded that the livestock farmers need to incur cost and obtain consequent benefits while adopting for climate change. From this backdrop, current study suggests that the available climate adaption techniques need to be investigated in detail and associate real-time cost and benefit analysis should be performed using the proposed conceptual model under local conditions to develop effective local policy decisions.

Keywords: adaptation measures, climate change, heat-stress, sustainability

The Effect of Different Fruit Bagging on Post- Harvest Quality of Guava

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Post-harvest techniques affect the quality of fruits and vegetables, and which determines the consumer acceptability. Hence the postharvest techniques should be improved to get maximum profit by the marketing agricultural products. Fruits are mainly consumed as raw so which cultivars require specialized post-harvest technologies to get good quality fruits. This study was conducted to improve the post-harvest quality of Guava fruits through application of different fruit bagging materials. Five treatments were conducted such as brown protective paper bags, white protective paper bags, transparent polythene bags, blue polythene bags and Newspaper bags to cover the fruits. The temperature variation, physical parameters (weight, volume and diameter), physiochemical parameters (firmness, peel color, pulp color, total soluble solid (TSS), titratable acidity (TA), pH and microbial pathogens were analyzed after harvest with different treatments. Qualities of fruits were observed by visually and organoleptic parameters were evaluated by sensory analysis. Temperature variation, physical parameters (weight, volume and diameters) showed significant difference ($p < 0.05$) Physiochemical parameters such as firmness, PH, *a value of peel color, * L value and *b value of pulp color didn't show any significant different ($p > 0.05$) among different fruit bagging materials during fruit development period. The fruit in brown protective paper bags gave maximum weight, diameter and volume. Blue polythene bags showed maximum titratable acidity (TA), firmness, pH and lower total soluble solid. According to microbial pathogens analysis, bacterial infection was observed in polythene bags, transparent polythene bags and paper bags and physical damage was observed in all treatments. According to sensory evaluation the fruits in brown protective paper bags showed better taste and texture and blue polythene bags showed better color, odor and shape of fruit.

Keywords: Fruit bagging material, Guava, Physicochemical parameter, Physical parameter, Post-harvest quality

Phenotypic Plasticity of Wild Rice (*Oryza nivara*) Between the Native and Introduced Environments in Sri Lanka

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Wild rice species, *Oryza nivara* is the progenitor of Asian cultivated rice and has been recognized as a valuable genetic resource for rice genetic improvement. In Sri Lanka, reciprocal transplant studies of wild rice species are limited. This study fulfils the knowledge gap on morphological variation of *O. nivara* grown in native and introduced environments for evaluating phenotypic variation for local adaptation. The reciprocal common garden experiment was conducted in the dry (Hambantota: N6.232684, E81.147097) and wet (Akuressa: N6.162225, E80.42886) zones of Sri Lanka. Phenotypic plasticity was measured by 8 quantitative traits following the rice descriptor published by IRRI. The independent t-test revealed that the all quantitative traits of *O. nivara* showed a significant difference between the dry and wet zones. According to the results, significantly highest culm length (78.4 ± 11.2 cm), anther length (3.38 ± 0.34 mm), awn length (66.9 ± 14.9 mm), panicle length (24.66 ± 3.25 mm), and plant height (101.2 ± 23.3 cm) were recorded in the wet zone. However, the dry zone showed the significantly highest culm diameter (8.21 ± 1.23 mm), flag leaf angle (85°), and horizontal distribution (145.0 ± 17.4 cm) compared to the wet zone. *Oryza nivara* was mostly confined to the dry zone thus, its phenotype was more prominent in the wet zone when compared to its native habitat. The investigation of phenotypic plasticity provides a new clue for the local adaptation and speciation studies and the effective use of wild stains in the development of location-specific modern cultivars.

Keywords: Wild rice, phenotypic plasticity, morphological diversity, local adaptation and speciation, reciprocal experiment

Trichoderma asperellum*, A Potent Nematode Antagonist of Root-knot Nematode, *Meloidogyne incognita

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Tomato (*Lycopersicon esculentum* Mill.) is often infested with an endoparasitic nematode *Meloidogyne incognita* which causes yield loss between 25 to 100% depending on the cultivar and abiotic factors. Managing the nematode pest is a challenging problem. As most chemical nematicides have been withdrawn from the global market due to environmental concerns, biological control is receiving increasing attention. Among the bioagents, *Trichoderma* species are potential nematode antagonists. In our attempt to identify a potential nematode antagonistic *Trichoderma* sp. from Indian soils, screening bioassays on juvenile mortality were conducted using thirteen *Trichoderma* isolates from 5 states of India. An isolate of *Trichoderma* that exhibited significant egg hatch inhibition and antibiosis was identified as *T. asperellum* based on *ITS4* and *ITS5* regions and its gene sequence submitted to NCBI database to get an accession no. MT702882. Addition of fresh fungal broth in soil at the rate of 3% (w/w), resulted in significant reduction in juvenile invasion, reproduction factor, and root galling compared to uninoculated control with visible enhancement in plant growth parameters in tomato cv Pusa Ruby. The test isolate was proved to be an endophyte. In an effort to develop a stable oil-based formulation of the *Trichoderma* isolate, the sporulation of the isolate was enhanced and the compatibility with 5 oils and 5 emulsifiers was evaluated. Three formulations (F1, F2, and F3) were developed, each with a spore load of $2 \times 10^{11}/\text{cm}^3$ and their pH, viscosity and sedimentation rate were evaluated. The soil application of F1 and F2 at 3% (w/w) reduced nematode galling by 42.9 % and 31.7 %, respectively, in tomato cv Pusa Ruby. Both the formulations exhibited significantly higher number of colony forming units (cfu) on storage at 15 °C, than at 25 °C or 30 °C. Thus the *T. asperellum* bioformulation were found effective against *M. incognita* infecting tomato.

Keywords: *Trichoderma asperellum*, *Meloidogyne incognita*, Bioformulation

Evaluation of Essential Oils and their Components for Broad-Spectrum Antifungal Activity against *Pythium aphanidermatum*, Causing Damping-off Disease in Tobacco

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Synthetic fungicides are currently used as primary means for the control of plant disease. Besides, the inherent hazards and negative public perceptions about the synthetic chemicals, using of essential oils as novel alternative inhibitory agents against phytopathogens. Essential oils are complex mixtures of hydrocarbons and their oxygenated derivatives arising from two different isoprenoid pathways. The antimicrobial activity of essential oils reduces hyphal growth and also induces lysis and cytoplasmic evacuation in fungi. With this background, The antifungal properties of 6Eos, includes citronella (*Cymbopogon nardus*), lemon grass (*Cymbopogon citratus*), clove (*Syzygium aromaticum*), thulsi (*Ocimum tenuiflorum*), castor (*Ricinus communis*) and *Eucalyptus* (*Eucalyptus globules*) oil were screened. The oils are tested in liquid bioassay (Poison food technique) for confirmation. The test oils at 0.1- 1.00 percent (v/v) were prepared and added to the flasks separately. Tween 80 at 0.01 percent was used as a surfactant to disperse the oil. The contents were thoroughly mixed by placing the flasks on a shaker at $28 \pm 2^\circ\text{C}$. *P. aphanidermatum* (9 mm) culture was aseptically introduced into flasks. The inhibitory effect of oils showed dose-dependent activity on the tested fungus. Based on the MIC Values, *Eucalyptus*, clove, thulsi and citronella were the most effective. With regard to the essential oils screened, *Eucalyptus* oil at (0.1 percent) was found to be superior to other oils tested against *P. aphanidermatum* (isolate Pa₅). We observed MIC minimum inhibitory concentration in *In-vitro* assay. Mode of action involves induction of changes in cell wall composition plasma membrane disruption, mitochondrial structure disorganization. This study warrants further research into the practical use of EOs for the control of important phytopathogens in intensive Agriculture

Keywords: Essential oils, MIC, *Pythium aphanidermatum*, Inhibition, Tobacco

Effectiveness of Cinnamon Bark Oil under *In-vitro* Conditions to Control *Phomopsis* sp. Isolated from Guava (*Psidium guajava*)

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Phomopsis rot in guava is a common postharvest disease found in Sri Lanka that cause major economic problems and need alternative treatments for fungicides. Also cinnamon has proven significant control over some postharvest pathogens. This experiment was conducted to identify the effective concentrations of cinnamon bark oil to control *Phomopsis* sp. isolated from guava fruits collected from the dry zone of Sri Lanka. Effect of selected concentrations (500, 600, 700, 800, 900 and 1000 μL^{-1}) of cinnamon bark oil was evaluated using poisoned food bioassay on potato dextrose agar medium (PDA). A minimum inhibitory (fungistatic) and minimum lethal (fungicidal) concentrations were identified with the regrowth ability in fresh PDA medium. Radial mycelial growth, growth rate and inhibition percentage were recorded on daily basis. The experiment was conducted as completely randomized design with three replicates per treatment. Analysis of variance (ANOVA) was used with the statistical software SPSS 20.0 to analyze the experimental data. Radial mycelial growth was significantly different ($p < 0.05$) among the treatments where no growth was observed in 700, 800, 900 and 1000 μL^{-1} concentrations of the cinnamon bark oil. By 3rd day of incubation, mycelia covered the PDA media completely in control plates whereas the radial growth of mycelia were 5.50 ± 1.56 and 4.75 ± 0.66 in 500 and 600 μL^{-1} concentrations, respectively. The highest growth rate (17.75 ± 1.00 mm per day) was observed in control samples at the 2nd day after inoculation to PDA medium. Lowest growth rate was observed in 600 μL^{-1} from the concentrations where mycelium growth was observed. Inhibition percentages on 500 μL^{-1} and 600 μL^{-1} concentrations were 86.50% and 88.34%, respectively, at the 3rd day after inoculation where it was 100% in all other concentrations. Minimum inhibitory concentration was 700 μL^{-1} and the minimum lethal concentration was 900 μL^{-1} for *Phomopsis* sp. isolated from guava fruits. It can be concluded that cinnamon bark oil contains phytochemicals which can be used to control *Phomopsis* sp. isolated from guava fruits under *in-vitro* conditions. Further *in vivo* trials with the most effective concentrations of cinnamon bark oil are necessary to find out their applicability as a postharvest treatment for guava fruits.

Keywords: Essential oils, Fruit rot, Fungicides, Postharvest loss, Postharvest diseases

Evaluation of Rhizobacterial Isolates Antagonism to *Meloidogyne incognita* Infecting Tomato

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Tomato is one of the most widely cultivated vegetable in the tropical and subtropical regions of the world. Root-knot nematode (RKN) species, *Meloidogyne incognita* and *M. javanica* are serious constraints to vegetable crops, especially tomato under protected cultivation, causing yield loss up to 25-100%. In the present study rhizobacterial isolates from polyhouse tomato cultivars were isolated and assessed for *M. incognita* antagonism. Among 80 isolates that were tested for mortality of *M. incognita* juveniles (J2s). The results show that cell free filtrate (CFF) of four rhizobacterial isolates (*B. pumilus*, *B. megaterium*, *B. cereus* and *B. subtilis*) caused high mortality (>90%) in *M. incognita* J2s on exposure at 24h. Egg masses kept in CFF showed significant ($p < 0.05$) hatch inhibition in the range of 85.04 to 100% compared to control, on incubation for 21 days. Among the treatments, *B. subtilis* caused maximum inhibition (88.6-100 %) followed by *B. pumilus* (83-100%), *B. cereus* (81.5-94.7%), and *B. megaterium* (78.83-90.7%) as compared to control. Pluronic gel bioassays using tomato seedlings (cv Pusa Ruby) revealed that significantly reduced ($p < 0.05$) juvenile (J2s) attraction towards the rhizobacteria treated roots on observation at 2h and 4h. The maximum inhibition was observed with *B. subtilis* treatment where an average numbers of J2s that reached a distance of 0.5-1.0 cm were 15-20 at 2h in treated plates as compared 29 -30 in control treatment.. The rhizobacterial isolates were significantly ($p < 0.05$) reduced nematode infection. Thus the rhizobacterial isolates were antagonistic to *M. incognita* in tomato. Their utilization in polyhouses is a promising approach for management of *M. incognita* in tomato.

Keywords: *Bacillus pumilus*, Rhizobacteria, Egg hatch inhibition, *Meloidogyne incognita*, Tomato.

Methods to Improve Seed Sets in Cluster Onion Hybridization

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Onion is an economically valuable vegetable crop which is naturally cross-pollinating entomophily with two crop cycles as seed–bulb and bulb–seed. Seeds and bulbs are the primary propagation materials in bulb production. A cluster onion hybridization experiment with reciprocal crossing parental combination has been carried out since 1996 at Regional Agricultural Research and Development Centre, Killinochi. Hybrids onions do have a several benefits, but they usually produce less seeds than open pollinated cultivars. Accordingly, this study was conducted to determine the method/s to improve the seedsets in cluster onion hybridization. Hybridization was made between the three lines namely MH4, MICLO1, TVM6 and the parents were subjected to treatments with combination *viz*, vernalization, non-vernalization, covered by shade insect proof net, open environment, with and without Indole Acetic Acid application using Randomized Complete Block Design. Vernalized covered IAA application (V.CO.IAA), vernalized covered without IAA application (V.CO.NIAA), vernalized opened IAA application (V.NCO.IAA), vernalized opened without IAA application (V.NCO.NIAA), non vernalized covered IAA application (NV.CO.IAA), non vernalized covered without IAA application (NV.CO.NIAA), non vernalized opened IAA application (NV.NCO.IAA), non vernalized opened without IAA application (NV.NCO.NIAA) were the eight treatment combination effected. Seed set percentage was recorded from those different eight treatment combination with their reciprocal crossing were analysed in ANOVA using SAS programme. The results revealed that significantly high seedset percentage on vernalized IAA application (83.89%) when crossing between MH4 with MICLO1 than that of non-vernalized uncovered without IAA application (51.92%). The same treatment had significantly higher seedset percentage in reciprocal crossing as well (83.02%). Vernalized IAA application had more significant impact on seedset percentage in MH4 crossing with TVM6 (80.76%) & MICLO1 crossing with TVM6. Among all varietal crossing vernalization and IAA application impact on seed set percentage. However, each varietal crossing covering was not significantly impacted on seedset percentage but covering is more advantageous to minimize the spread of disease while hybridization in cluster onion.

Keywords: Cluster onion, Vernalization, Indole Acetic Acid (IAA)

A Farmer Participatory Study to Identify the Ideal Location/s for Promotion of True Seeds of Cluster Onion (*Allium cepa*.L.) in Jaffna District of Sri Lanka

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During the *Maha* season of 2020/21, a farmer participatory research project was conducted to determine ideal location/s for the production of true seeds of cluster onion (*Allium cepa*.L.) in Jaffna district of Northern region. During the cropping period, eight trial plots were created in farmer's fields representing different climatic and soil conditions. The 11 agronomical parameters were recorded in relation to true seed production potential and bulb yield. In addition, an arbitrary model was evaluated for long-term seed availability without change in the genetic makeup of the cluster onion cultivar *Vethalam*. Bulbs were planted on 80% of their area for true seed production and the rest 20% for bulb production in this approach. pH, EC, Organic Matter, Available Phosphorous, and Exchangeable Potassium were measured in soil samples collect from each unit. The soil pH and Exchangeable potassium content varied throughout the locations, according to soil analysis. Fifty percent flowering, productive stalks per plant, umbel with, Stalk height, days to maturity for seed harvesting, number of harvesting, number of mature seeds per umbel, number of immature seeds per umbel, seed yield, and germination were all significantly different between some of the locations tested. Increased number of harvests have increased the number of mature seeds per a flower. Number of mature seeds per umbel varied significantly and the experiment plot at Araly showed highest maturity seeds (138/umbel). Four locations viz; Arali (250.75 kg/ha), Kaithady (213.25 kg/ha), Pandathrippu (185.37 kg/ha) and Urumpirai (145.37 kg/ha) in Jaffna district have proven with acceptable true seeds production. Bulb yields of all location were reached above 11 t/ha. Tested model, leaving 20% of the land for bulb production and rest of the land for true seed production, has proven efficient for seeds sustainability.

Keywords: Arbitrary Model, Farmer Participatory, True Seed Production, *Vethalam*.

Controlled Storage Conditions Reduce the Postharvest Losses of Big Onion (*Allium cepa*) Selection “Dambulla Red”

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Postharvest loss of big onion is considerable and one of major issues which adversely affects food security in Sri Lanka. One of major reasons is improper storage conditions where, mainly due to harvesting coincides with rainy season or harvest just before rainy season. Hence, storage of harvested onion is critical in rainy weather where high relative humidity prevails during second inter-monsoon and *Maha* seasons. Temperature (T) and relative humidity (RH) should be controlled to reduce postharvest loss of big onion during storage period. Therefore, this experiment was conducted to evaluate the effect of controlled temperature and relative humidity on postharvest loss of big onion during storage period. Ambient storage (AS) (partially rainy day: 30.05±1.48 °C, 79.31±3.76% RH; Sunny day: 33.99±1.86 °C, 57.06±8.88% RH) and controlled storage (CS) (27.15±0.41°C, 70.57±7.3% RH) were used as treatments with complete randomized design with three replicates (150 kg each). Onions were harvested from selected fields in Anuradhapura district, Sri Lanka and subjected for shade curing. Physiological weight loss (PWL), Rotten percentage (RP), Sprouted percentage (SP), Total soluble solids (TSS), Total color difference (TCD) and Total postharvest loss (TPL) were recorded for six weeks period. No significant differences ($p > 0.05$) were observed for PWL and TCD between treatments. PWL of onions in AS and CS were 9.32±1.38 and 9.16±0.94% respectively. However, there were significant differences ($p < 0.05$) observed for TSS, SP and for RP between treatments. RP of onions were 8.09±0.19 and 5.46±0.17% in AS and CS respectively. There was significant difference ($P < 0.05$) observed for TPL after the storage period where, 24.85±1.04 and 19.45±0.92% in AS and CS respectively. It can be concluded that the control storage conditions (27.15±0.41°C, 70.57±7.3% RH) could be used to reduce the postharvest losses of big onion during storage. However, temperature and relative humidity should be optimized with further experiments.

Keywords: Condiments, Onion Storage, Postharvest Life, Shelf life

Exploring Secondary School Students' Understanding of Solid Waste Management; a Case of Uyangoda Maha Vidyalaya, Kamburupitiya

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There have been few studies that have documented waste management issues in Sri Lankan educational institutions, particularly student perspectives. This study assessed the students' awareness of solid waste and their current solid waste management practices. It is majorly identified the challenges of maintaining effective solid waste management practices and analyzed the students' preference to maintain recommended solid waste management system. Grade 10 students (N=100) from *Uyangoda Maha Vidyalaya, Kamburupitiya* in educational zone of *Mulatiyana-Hakmana* were selected as the population and 35 students were randomly selected as the sample. The sample was surveyed using a structured questionnaire in January 2022. Mainly descriptive statistics were used to analyze the data. As per the results, considering the students' level of awareness regarding solid waste, the majority of students (42.8%) were aware of solid waste management while 22.8% had a full awareness. Lack of interest is the main challenge for the majority of students (40%) to maintain effective solid waste management practices. 25.7% of the respondents stated that lack of guidance was a challenge for solid waste management while 20% of them indicated that lack of knowledge was the main challenge. Moreover, 14.3% of the school children mentioned that inadequate space has become a major challenge for sustainable solid waste management practices. School children mainly suggested implementing recycling system and proper waste management system as means to manage solid waste. This exploratory study is of great significance for in depth further studies for implementing public investment decisions to improve the quality of solid waste management systems in Sri Lanka and to increase students' awareness of waste management issues and practices.

Keywords: Knowledge, Solid waste management, Students, Understanding, Awareness

Applicability of Mechanical Drying as a Thermal Pre-treatment for Minimizing Broken Rice Percentage in Rice Milling Industry

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Damaged and cracked grains are abundant in combine harvesting method due to subsequent harvesting and threshing operations at high speeds. Cracks on grains adsorb moisture from the storage environment and impose negative effects on head rice yield due to high moisture contents (over 18%). Milling of same paddy with favourable moisture contents after 2-5 months shows high broken rice percentage. Thermal pre-treatments, prior to milling, is effective in minimizing the broken rice percentages by maintaining the favourable moisture contents in mechanically harvested paddy. It is expected to find out the best thermal treatment condition for mechanically harvested paddy to reduce the broken rice percentage. Paddy samples harvested mechanically using a combine harvester were subjected to thermal pre-treatments at 50 °C, 60 °C and 70 °C using a hot air oven. Thermal exposure time durations of paddy samples were one, two and three hours. The effects of the mechanical drying treatments were evaluated on percentage of brown rice, percentage of polished rice, percentage of broken rice, hardness of brown rice and moisture content. Mechanically harvested paddy samples, subjected to direct milling, were maintained control of the experiment. Control rice samples reported highest significant broken rice percentage of 35.55 and lowest significant hardness value of 2.91. The control samples reported brown rice percentage of 78.92 and polished rice percentage of 90.49. Subjecting mechanically harvested paddy to 60 °C for two hours has shown lowest significant broken rice percentage of 21.9 and highest significant hardness (N) of 5.02±0.01. The same treatment reported the brown rice percentage of 74.28 and polished rice percentage of 90.43. The grain moisture content of the samples after the treatment was 12.01%. The results revealed that the broken rice percentage had been greatly reduced and hardness of milled rice is increased with the introduction of mechanical drying at 60 °C for two hours.

Keywords: Broken rice percentage, Mechanical drying, Milled rice, Thermal pre-treatment

A study on Water Management Issues in the Eastern Slopes of Central Highland Region, Sri Lanka

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Agriculture is the single most activity that consumes the largest portion of available water resources in Sri Lanka. Industrialization, population pressure and urbanization have also resulted in a rising demand for water leading to water use issues in the country. Climate-vulnerable localities with varied and large number of water uses and water user groups are much prone to water-related issues. The present study attempts to ascertain the water use related issues in the climate-vulnerable Eastern slopes of the central highlands. To collect primary data, a questionnaire survey was administered for a total of 357 farm households in the *Kurunduoya* and *Beliuloya* river basins in the Nuwaraeliya district. In addition, information was collected from different stakeholders in the agricultural and other sectors, and the estate communities. Land use change analysis revealed that over the past four decades, the settlements (133%) and market gardens (43%) where the cash crop cultivation is intensively undertaken have significantly increased by converting marginal tea lands, scrub lands and the stream reservations in the mid and upstream areas of the *Kurunduoya* basin. Absence of a mechanism for fair allocation of water among a large number of water users have made the communities in the downstream areas disadvantageous. Thus, the cultivation extent of irrigable lands in *Yala* seasons has diminished by 27% and 16% in minor and major irrigation areas respectively. The increased and non-regulated water use in upstream areas has been threatening the primary source of income and household food security of the communities in the downstream. Adequate interventions by government authorities and the mediation by the plantation management with the involvement of farmer organizations and community leaders in the plantation sector have a major role in planning and execution of appropriate water management mechanisms at different water user groups along the river basin and the slope for a fair allocation of water among different water user groups.

Keywords: Central highlands, Eastern slopes, Land use, Water allocation

Thermal Treatments as Accelerated Aging Technique for Mitigating Rice Stickiness of Freshly Harvested Paddy

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Accelerated ageing is an artificial technique that induces ageing effect in fresh paddy within a short period of time while reducing the holding costs for millers. Thus, the aim of the study was to check the suitability of dry and steam heat treatments separately, as two accelerated aging approaches to mitigate the stickiness of freshly harvested paddy with preserved physicochemical and cooking properties. Freshly harvested cleaned *Bg352* paddy variety was subjected to dry heat treatments using a hot air dryer at different combinations of temperatures and drying times (60, 80 and 100 °C for 2, 4 and 6 hours) and steam heat treatments using mini boiler at different combinations of steam pressures (SP) and exposure times (SP; 0.5, 1.0 and 1.5 Kg/cm² for 5, 7.5 and 10 minutes). The samples were milled to study milling, physico-chemical, cooking and textural characteristics of rice. Rice stickiness of freshly harvested paddy was 3.23 ± 0.03 . In dry heat treatment method, exposing of freshly harvested paddy to 100 °C for 0.5 hours has shown the significantly highest reduction in rice stickiness from 3.23 ± 0.03 to 0.71 ± 0.03 . The results revealed that the yield %, Water Uptake Ratio, Elongation Ratio, Solid Loss, Cooking Time and Whiteness Index were not significantly different ($p > 0.05$) between naturally aged and treated paddy under 100 °C for 0.5 hours but, were significantly different ($p < 0.05$) for broken rice%. In steam heat treatment method, freshly harvested paddy subjected to 1.5 Kg/cm² for 10 minutes has shown the significantly highest reduction in rice stickiness from 3.23 ± 0.03 to 0.67 ± 0.03 while it has preserved the favourable parameters than the dry heat treatment. In conclusion, both dry and steam heat treatments accelerate the artificial aging of fresh paddy while steam heat treatment preserve the quality at significantly highest levels.

Keywords: Accelerated aging, Dry heat treatment, Steam heat treatment, Stickiness

Different Parboiling Process Effect on the Formation of Resistance Starch in Raw Paddy Varieties

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The parboiling process leads improves rice quality and enhances the physio-chemical properties of grains. Parboiled rice exhibits several advantages over raw rice products, such as strengthening kernel integrity by forming resistant starch, increased milling recovery and preventing the loss of nutrients. Two Department recommended varieties with red pericarp (*At362*), white pericarp (*Bg366*) and one industrial type with red pericarp (Adakari) were used for investigation in this study. Paddy samples were prepared in different duration and methods of soaking and steaming with controls (Raw rice). Different parboiling practices were investigated on their milling yield qualities, refers as Head Rice Yield (HR) and resistance starch formation (RS) during cooking. Initially, raw paddy samples were soaked in cold water at the intervals of a day, 2 days, 3 days, 4 days, and 5 days with a volume ratio of 1:1.5 and the steaming procedure was practiced for 20 minutes duration as Soak Steam (SS), Pressurized Soak Steam (PSS), Un-soaked Steam (USS) in an electric rice cooker with steamer. The parboiled paddy was dried under a conventional oven at 60 °C temperature for 3 hrs., which achieved a suitable moisture level for safe milling. An extrusion test was performed to test the internal strength of the rice kernel after cooking. Cooking of Parboiled rice was performed with water in a volume ratio of 1:1.2, duration of 20 minutes in an electric rice cooker. The running temperature of the extruder was 30 °C, and the speed was 30 rpm. There was a rice kernel had high resistant starch content extrusion test yield outcome is low. The Highest head rice yield was counted in the Pressure-soaked steam (PSSP) method with 2 days of soaking duration (48 hrs). Pressure-soaked steam (PSS) samples show a lower extrusion outcome than other parboiling methods, yielding good resistant starch parboiled rice. All other parboiling methods gave moderate head rice yield and extrusion outcome. Raw rice samples show a higher extrusion outcome and lower resistant starch than parboiled rice samples.

Keywords: Extrusion test, Resistant starch, Head rice yield, Paddy soaking & steaming.

Simulation Techniques and Modelling of Optimized Pressurized Agriculture Pipe Network Suitable for Home Gardening in Vavuniya Area of Sri Lanka

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Home gardening is identified as one of the remedial measures for food security issues caused by the economic downfall in Sri Lanka. Home gardening contributes to household food security by providing direct access to food. Further, it is also an important source of supplementary income for households. The appropriate function of a pressurized agriculture pipe network system is vital to supply a sufficient quantity of water to the plants at sufficient pressure through the sprinkler output. Despite this, very few computer simulation techniques studied for optimization for the case of the home gardening agricultural pipe system. In this study, the WaterGEMS V8i software simulator was used and hydraulic analyses were conducted to design an optimal pressurized agriculture pipe network suitable for home gardening in the Vavuniya area. The water flow rate at sprinkler outlet points for chilli and onion were considered 600 L/h and 325 L/h respectively. The total available land area for home gardening was considered as 50 perches in this study. Fifteen models were developed for different combinations of land use for chilli and onion cultivation. The hydraulic parameters such as nodal pressure, flow velocity, flow rate and head requirement were analyzed under steady-state simulation by using the Hazen-Williams friction method. The proposed simulation model was calibrated and validated by using a previous study. The result revealed that all of the nodes in the system are operating above the threshold pressure limit of 2 bars. It was found that a combination of 20% land (10 perches) for onion and 80% land (40 perches) for chilli required the highest power pump capacity of 3.5 kW. The power of the water pump for chilli only and onion only was positively correlated with the cultivated land extent and R^2 values were observed to be 0.9991, and 1.0 for chilli and onion respectively. The flow velocity in all pipes was above the minimum level of 0.5 m/s eliminating silt deposition and below the maximum level of 2.0 m/s avoiding the water hammer issues. The proposed pressurized agriculture pipe network design shall be used for modelling of pipe network for home gardening with different crop types by changing the model input parameters by using the WaterGEMS V8i computer simulator.

Keywords: Home gardening, Optimal design, Sprinkler irrigation, WaterGEMS V8i

Soil Carbon Sequestration Potential of Dry-Zone Home Gardens in Anuradhapura District, Sri Lanka

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Home gardens are an integral component of dry zone agroecosystems of Sri Lanka. These sequester atmospheric CO₂ and thereby contribute to mitigate global warming, but agricultural practices performed in these are believed to be disturbing the soil, resulting the release of stored soil carbon to the atmosphere. Further, soil organic matter affects the retention of soil nutrients. Thus, the amount of soil carbon, and the available nitrogen and phosphorous contents in the soils of home gardens could vary with the management inputs. Therefore, the C sequestration capacity in the soils (0–15 and 15–30 cm depths) from three types of dry zone home gardens (intensely managed over a long period of time, poorly managed over a long time and intensely managed but recently established) in Anuradhapura District in the North Central province of Sri Lanka were studied in relation to major management interventions operated in these. The total organic carbon (TOC), Labile soil organic carbon (LC), Microbial Biomass carbon (MBC) Water soluble carbon (WSC), available phosphorus, NH₄⁺ nitrogen and NO₃⁻ nitrogen contents in 108 randomly selected pooled soil samples (a composite of three) were detected by performing standard protocols, and the soil carbon stocks (SCS) in these three home gardens were estimated. TOC, LC, WSC and MBC contents in upper soil layers of more intensely and less intensely managed home gardens did not vary significantly ($p > 0.05$). Also, the SCSs do not vary significantly with the intensity of agricultural practices in these home gardens. However, the examined home gardens appear to be sequestering carbon at a substantial level, ranging from 21.17–23.81 Mg ha⁻¹ in the top-soil, but compared with this, the carbon stock is lower at the 15–30 cm soil depth (14.27–18.82 Mg ha⁻¹). The available phosphorous content at 0–15 cm soil depth, and the available phosphorous, NH₄⁺ nitrogen and NO₃⁻ nitrogen contents at 15–30 cm soil depth in intensely managed home gardens were higher ($p < 0.05$) than that in less intensively managed home garden, and this can be attributed to the addition of chemical and organic fertilizers to the top-soil and subsequent leaching of nutrients to the subsoil.

Keywords: Agroecosystems, Carbon stock, Microbial biomass carbon, Management

Chemical Properties of Rice Soils Managed under Organic or Inorganic Fertilizer Applied Conditions

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Over the past decade, paddy cultivation in Sri Lanka mostly rely upon chemical based conventional farming practices. Although it has substantially increased crop yields, they have adversely affected the environment and pose a threat to human and animal health. Moreover, physical and chemical properties of paddy soils managed under organic and conventional farming practices are not recently explored. Issues arising due to conventional agricultural practices and current government agriculture policy decisions have motivated organic paddy cultivation in Sri Lanka. Therefore, it is imperative to compare the nitrogen (N), phosphorus (P), potassium (K) and organic matter (OM) contents of paddy soils managed under organic and inorganic/conventional conditions. Hence, the objective of the current study was to compare the nutritional status of the inorganic or organic fertilizer applied paddy soils from three districts in Sri Lanka. Total of 44 soil samples (*i.e.*, 27 organically and 17 inorganically managed) were collected representing paddy lands in Anuradhapura (11), Polonnaruwa (8) and Gampaha (25) districts in Sri Lanka. Nitrogen, P, and K concentrations, and OM content of the soil samples were measured using Kjeldahal, Olsen, Flame photometric and Walkley and Black methods, respectively. Electrical conductivity (EC) and pH of the samples were measured using pH and conductivity meter. There was no significant ($p > 0.05$) interaction between districts and the type of fertilizer applied to determine the level of N, P, K, OM, pH and EC in soils. However, the main effect of district was significant ($p < 0.05$). Gampaha district recorded the significantly highest N, K and OM content than other districts ($p < 0.05$). Soils collected from Polonnaruwa district recorded higher P concentration over the other two districts. There was no significant difference in soil N, P and K concentrations between the fields managed under organic and inorganic conditions ($p > 0.05$) while the OM content was higher in organic fertilizer applied fields than the inorganic fertilizer applied soils. Soils collected from these districts were acidic in nature (pH; 3.6 to 5.9). The mean EC level of the soil was $76 \mu\text{S cm}^{-1}$ and ranged between $24\text{--}254 \mu\text{S cm}^{-1}$. Understanding this spatial variability of soil fertility as affected by the type of nutrient management system adopted is important when making agronomic decisions for sustainable paddy cultivation in Sri Lanka.

Keywords: Inorganic, Organic, Organic Matter, Paddy

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Distribution of Potassium in Selected Paddy Soils and their Variation under Different Agro-Climatic Zones, Management Practices and Soil Orders

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Potassium (K) is an essential macro nutrient for growth and production of rice (*Oryza sativa* L.). Exchangeable K fraction is the available form of K for plants. However, exchangeable K concentration in rice growing soils can vary with climatic factors, water management practices, cropping systems and soil properties. Hence, the objective of this study was to determine the variation in lowland soil exchangeable K concentration among six agro-climatic zones (ACZs), water supply systems (major irrigation, minor irrigation and rainfed), rice-based cropping systems (banana, vegetable, other filed crops and fallow) and soil orders (Vertisol, Alfisol, Entisol, Histosol, Inceptis and Ultisol). Total of 1200 paddy soil samples were collected using a stratified random sampling approach. Each sample consisted of six soil cores obtained from the top 15 cm of the soil profile of a paddy track (*Yaya*) considering topographical heterogenities. Exchangeable K in soil was extracted using 1 M ammonium acetate and determined using flame photometer. Soil exchangeable K concentration was ranged between 26.4 – 1133.8 mg kg⁻¹ with a mean concentration of 240.1 mg kg⁻¹. Exchangeable K concentration was similar among different ACZs ($p > 0.05$). When compare water sources, the highest and the lowest exchangeable K concentrations were recorded in minor irrigation and rainfed areas, respectively ($p < 0.05$). Rice-banana cropping system had higher exchangeable K concentration than continuously paddy cultivated lands ($p < 0.05$). Further, the highest exchangeable K was observed in Vertisol followed by Alfisol and Entisol ($p < 0.05$). Among all the soil orders tested, Ultisol reported the lowest exchangeable K concentration ($p < 0.05$). In summary, most of the paddy growing soils in Sri Lanka have sufficient amount of soil exchangeable K (i.e., optimum K level in soil is 40 - 80 mg/kg) without causing K deficiencies to rice plants. Exchangeable K concentration varied among water sources used, rice-based cropping systems adopted and soil orders.

Keywords: Cropping systems, Exchangeable potassium concentration, Irrigation methods, Paddy, Soil orders

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Comparative Study on Heavy Metal Accumulation in Sediment Samples in China, India and Sri Lanka

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Due to anthropogenic activities heavy metals in the environment tend to reach concentrations which are not permissible, causing adverse health conditions. These elements enter into the human body through dermal, inhalation, and ingestion pathways and may create carcinogenic, mutagenic and teratogenic toxic effects. Due to their ubiquitous nature, persistence and nonbiodegradability, and Toxicity in humans, and due to over exposure to heavy metals results in bioaccumulation and bio-magnification along food chains and ultimately lead to destruction of organisms and ecological systems. Excessive heavy metal accumulation in agricultural soils may lead not only in soil contamination but also affect food quality. Therefore, this review was done to identify the heavy metal accumulation on three selected samples of the Asian countries: Sri Lanka (Colombo city dust), China (Dongting Lake) and India (Pondicherry) in order to derive basic understanding on the heavy metal accumulation. Research articles (132) were initially collected based on carcinogenic heavy metals in sediment. Colombo city dust has recorded the highest accumulation for Zn (339 mg/kg) and Cu (173.5 mg/kg) in Sri Lankan sediment samples. Then, two Asian countries India and China were selected based on the high rate of anthropogenic activities. However, depending on the sample location the heavy metal accumulations may vary. Hence, the evaluation is done to compare the heavy metal composition on the three sample sites. Pondicherry has recorded as having the highest Cr (334 mg/kg) accumulation in sediment samples, Ganges River in India was reported as having high-Ni (48 mg/kg) content while the Dongting lake in China recorded as having the highest concentrations of Zn (322.6 mg/kg), and Pb (57.96 mg/kg). In conclusion, accumulation of heavy metals among the three sediment samples, Colombo city dust in Sri Lanka is reported as the highest while the second highest is reported at Dongting Lake in China, and third highest at Pondicherry, India.

Keywords: Anthropogenic sources, heavy metal concentrations, sediment samples, soil toxicity

Effect of Cinnamon Wood Biochar Preparation Methods on Nutrient Retention and Release

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In Sri Lanka, farmers use inorganic fertilizer under the conventional farming methods. However, farmers have not been able to obtain the expected yield for a long time due to soil fertility problems associated with nutrient retention and leaching. Cinnamon wood has the potential to produce value added product like biochar. This study monitored the effect of different the cinnamon wood biochar preparation methods, namely, a with methods of cone pit method at 20 min and 45 min, a double barrel method for 1 hour, and a muffle furnace method for 1 hour at 400 °C and 500 °C on nutrient retention and release. Experiment was carried out over 1 month using a nutrient solution (20% Urea ($\text{CO}(\text{NH}_2)_2$), 10% Triple Super Phosphate ($\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O}$), and 10% Muriate of Potash (KCl)) at the rate of 1 L per column at the beginning and at the middle of the experimental period. The column only with the subsoil recorded the highest total Nitrogen (N), Phosphorus (P) and Potassium (K) in the leachate and showed the lowest nutrient retention in the media. The lowest total N, P and K in the leachate and the highest nutrient retention in the media were observed in the treatment that consisted of biochar prepared by the muffle furnace method at 500 °C. This method was found to be the best method to reduce nutrient leaching, while it also had the highest capacity to retain more nutrients. Regarding outcomes relevant to global agriculture, the results show that the cinnamon wood biochar preparation methods can affect nutrient retention and release while opening the possibility of using cinnamon wood biochar as a soil amendment.

Keywords: Biochar, Cinnamon wood, Nutrient leaching, Nutrient retention, Soil amendments

Prevalence of Gastrointestinal Parasitic Infection in Different Age Groups of Goats

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Goats are an excellent source of meat and milk for human consumption. Parasitic infestations lead to significant health concerns and huge economic losses in goat farming. The aim of the present study was to determine the occurrence of parasitism and to study the relationship between the prevalence of gastrointestinal parasites with age of the indigenous goats. The study was conducted at a livestock farm, at Puliyankulam, Vavuniya, Sri Lanka in March 2021. Eighteen indigenous goats were randomly selected and they were separated into three groups (n = 6 each group): (i) below one-year, (ii) one to three years, (iii) above three years. They were kept in an extensive management system with an improper deworming programme. Faecal samples were analysed to determine the eggs per gram (EPG) and oocysts per gram (OPG) of faeces by means of modified McMaster techniques and morphological differentiation was done by means of floatation techniques. All the tested samples were positive for either parasitic eggs or oocysts. Among those samples, protozoan, nematode and cestode species were found based on their morphological characteristics. Protozoan: *Eimeria* spp. was observed with the highest ($P < 0.05$) prevalence (56.26%), followed by Nematodes: *Trichostrongyle* spp. (29.90%) and *Strongyloides* spp. (9.72%) followed by Cestode: *Monezia* spp. (3.09%) and Nematodes: *Trichuris* spp. (1.03%). Based on this study, a significant difference was found ($p < 0.05$) among gastrointestinal infestations of different age groups. *Trichostrongyle* spp. was higher ($p < 0.05$) in below one-year goats (43.35%) followed by above three years goats (29.56%) and least was observed in one to three year goats (27.09%). Highest ($p < 0.05$) *Strongyloides* spp was observed in below one-year goats (59.09%), followed by above three year (36.36%) and one to three year goats (4.55%). Highest ($p < 0.05$) prevalence of *Trichuris* spp. was observed in above three year (57.14%), followed by one to three year (28.57%) and below one-year goats (14.29%). *Monezia* spp. was only observed in below one-year goats (100%). According to the study young indigenous goats were more susceptible to gastrointestinal infestations than matured.

Keywords: Age, Indigenous Goats, parasites, Parasitic eggs, Prevalence

Hatchability Prediction and Classification of the Eggs Based on the Physical Parameters of the Eggs

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Hatchery performance is critical for the profitability of poultry breeder operations. Some physical parameters of eggs and breeders cause to increase or decrease the Hatchability. The aim of this study is to identify the affecting physical parameters on the Commercial hatchability of local chicken eggs and to determine the most efficient classifying model to investigate whether the hatchability rate is greater than 90% or not. In this study, 674 breeder samples were considered, and seven physical parameters such as Egg weight, Moisture Loss, Breeder age, Number of Fertilized eggs, Shell width, Shell length, and Shell thickness were identified. After removing the outliers, the existing sample was split into ten splits, and 80% and 20% of them were used as training and testing samples, respectively. Multiple linear Regression was performed to determine the most influencing variable on hatchability. First, a correlation between each physical parameter and hatchability was checked. Then a multiple regression equation was developed, and the accuracy of the fitted model was evaluated. Linear Discriminant Analysis (LDA), Classification and Regression Trees (CART), k-Nearest Neighbors (kNN), Support Vector Machines (SVM) with a linear kernel and Random Forest (RF) algorithms were applied to classify the hatchability. Hatchability was negatively correlated with Egg weight, Breeders' age, Shell width, Shell length, and positive correlations were identified with Moisture loss, Number of Fertilized eggs and Shell thickness. Multiple linear regression models were more accurate than single linear models in terms of the highest coefficient of determination (R^2) with 94% and minimum Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values. According to the classification results, RF, CART and kNN had the highest accuracy values of 0.999, 0.975 and 0.972, respectively, for the commercial hatchery process. Therefore, the RF is the most appropriate machine learning algorithm for classifying breeder outcomes in a commercial hatchery, whether economically profitable or not.

Keywords: Classification, Hatchability, Physical parameters, Regression

Ginger Extract Supplemented Cow's Milk Ice Cream Development

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Ice cream is a globally popular frozen dairy product. It's usually prepared from cow's milk. Antioxidant and phenolic components are often lacking in commercially marketed ice cream. In order to increase the usage of ginger extract and thus add value to cow's milk ice cream, a study was conducted to look into the production and quality analysis of cow's milk ice cream with ginger extract. The cow milk ice cream was formulated with varied concentrations of ginger extract, according to preliminary study. The treatments were: cow's milk ice cream without ginger extract (T0), cow's milk (I) with 20 g ginger extract (T1), cow's milk (I) with 30 g ginger extract (T2), and cow's milk (I) with 40 g ginger extract (T3). All treatments were subjected to chemical and sensory evaluations. The treatments differed considerably in pH, total solids, total soluble solids, fat content, titratable acidity, and ash content ($p < 0.05$). As the concentration of ginger extract increased, the pH (6.67-6.47), total solids (36.9-35.55%), total soluble solids (28.87-27.65 Brix), fat content (9.25-8.82%), and ash content (0.75-0.51%) reduced, while acidity (0.18-0.29%) increased. In terms of color, taste, texture, aroma, and overall acceptability, the panelists preferred T2 with 30 g/l ginger extract, followed by T1. Based on the findings of an experimental investigation of freshly prepared cow's milk ice cream flavored with ginger extract, T2 was chosen to be the superior ice cream formulation.

Keywords: Cow's milk, Flavor, Ginger extract, Ice cream, Sensory properties

Study of Nutritional Characteristics of Silages from CO3, CO5, Red Napier (BH18) & Super Napier among Small Holder Dairy Farms in Kilinochchi District, Sri Lanka

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A study was conducted to examine the nutritive values of the silages made from major grasses available in the Kilinochchi District. Inadequate quality forage and the lower availability of forage crops is considered as a limiting factor for livestock production. Introducing of different silage grasses helps to overcome these problems all over the dry zone. In dry zone of the Sri Lanka, insufficient fodder production is one of the main factor restricting dairy production. Silage is a feed that has been preserved by acidification as a result of fermentation in the absence of oxygen. "Ensiled forage" or "silage," can remain intact for up to three years when storing properly. The lack of high-quality forages and their accessibility may be a factor in Sri Lanka for lower dairy productivity of livestock. In dry zone of the Sri Lanka, insufficient fodder production is one of the main factor restricting dairy production. The main objective of this study is to find out the nutritional characteristics of silage made from different grass (Indian red napier, CO5 grass and other napier grasses, CO3 and super napier) grown in Northern part of Sri Lanka. Proper matured grasses were harvested and four silage samples (T1,T2,T3 & T4) were prepared according to the standard procedure. The proximate composition of different types of silage made from different grasses were significantly different ($p < 0.05$). Among the silages, CO5 had the highest percentage of crude protein (CP) (16.07 %) and moisture (75.04 %) meanwhile super napier had the highest percentage of fiber (31.43%), lowest percentage of ash content (2.5%) and lowest percentage of fat content (1.16%). Based on the above results, we can conclude that super napier silage have higher nutrient value compared with other silages. Therefore the silage made from super napier can be suggested for the Kilinochchi district farmers to provide better yield and growth performances.

Keywords: Silage, Ensiling, Forage, CO3, CO5, Red Napier, Super Napier.

Prevalence of Ectoparasites among Cattle in Kilinochchi District

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Livestock sector has been contributing considerable portion to the economy of Sri Lanka, and still promising to play great role in the economic development of the country. Products and by-products come from livestock population is an essential source of income for the people who are living in Killinochchi district. There are several constraints found in cattle farming. Among them external parasitic infestation is one of the problem which affects the production adversely. Therefore, a cross-sectional study was conducted from March to July, 2022 with the objectives of determining the prevalence of ectoparasitic infestation in cattle and risk factors associated with ectoparasitism in Kilinochchi district. Total of 384 cattle (119 males and 265 female) were used to study the prevalence on live animals. The study revealed that cattle in the study area were infested with single infestation (6.7%) and multiple infestation (45.83%) with an overall prevalence of 52.60% (202/384). Overall eight genera of ectoparasites which belong to tick (47.89%), lice (4.45%) and mite (0.26%) were identified in flank, belly, shoulder, dorsal surface of the ear and along the dorsal side of the cattle. Among the genera of the ticks, *Amblyomma*, *Boophilus*, *Hyalomma*, and *Rhipicephalus* and three types of lice genera *Damalina*, *Linognathus* and *Haematopinus* were found. Only one genera of mite was identified namely, *Demodex bovis*. According to present study, three to seven years cattle were highly susceptible (49.50%) to ectoparasitic infestation compare to other age groups. In addition, highest prevalence (70.65%) was shown by female cattle. The cattle with the herd size of less than 14 were highly infected with external parasites (79.60%). The present study revealed that widespread occurrence of ectoparasites in cattle in the study area, thus, improved management practice and well-coordinated control interventions are required.

Keywords: Cattle, Ectoparasite, Lice, Mite, Prevalence

Use of Low Cost Biosorbents for Treating Wastewater from Aquaculture

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Aquaculture contributes to the economy of Sri Lanka significantly. Aquaculture industries are producing export quality products while generating employment opportunities. Unique location of Sri Lanka and its resources supporting aquaculture development immensely. Even though aquaculture supporting our economy through multiple ways, the main hindrance for the development of this industry is the pollution caused by aquaculture waste water. Chemical Oxygen Demand (COD) is the amount of oxygen required to oxidize all soluble and insoluble organic compounds present in a volume of water. This can be used to know the pollution status of an aquaculture system. The main objective of this study was to analyze the physical and chemical parameters of aquaculture waste water and reduction of the Chemical Oxygen Demand in the waste water using environment friendly biosorbents. Waste water was collected from a hatchery and physical parameters such as the pH, total dissolved solids, dissolved oxygen, turbidity, electrical conductivity and temperature were analyzed. In this study three bio sorbents and their combination were used to compare their COD removal efficiency (T1- *Musa* peel powder, T2 - Oyster shell powder, T3- Egg shell powder, T4 - 0.5g Egg shell mixed with 0.5g *Musa* peel powder, T5 - 0.5g *Musa* peel powder mixed with 0.5g Oyster shell powder, T6 - 0.5g Oyster shell powder mixed with 0.5g Eggshell powder). Results were analyzed using CRD design in SAS software. It was found that COD removal efficiency of *Musa* peel powder is high (92.63 ± 0.86) and significantly different ($p < 0.05$) from other treatments. Therefore can utilize *Musa* peel powder as an effective and low cost natural biosorbent.

Keywords: Aquaculture, Biosorbents, Chemical oxygen demand, Wastewater

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