"Networking for Smart Agriculture and Sustainability of Bioresources"

Proceedings of the International Symposium on Agriculture and Environment 2019

ISAE 2019

28th February 2019
The Blue Water Hotel
Wadduwa
Sri Lanka

PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON AGRICULTURE AND ENVIRONMENT 2019

Published by
Faculty of Agriculture
University of Ruhuna
Mapalana, Kamburupitiya 81100
Sri Lanka.

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Website www.agri.ruh.ac.lk

ISSN: 1800-4830

Preface

It is with great pleasure and privilege the Editorial Board unveils the Proceedings of the International Symposium on Agriculture and Environment (ISAE 2019). The theme of this year's symposium is "Networking for smart agriculture and sustainability of bio resources" which is currently a topic of great global significance. Agriculture has seen many revolutions, whether the domestication of animals and plants a few thousand years ago, the systematic use of crop rotations and other improvements in farming practice a few hundred years ago, or the "green revolution" with systematic breeding and the widespread use of man-made fertilizers and pesticides a few decades ago. We suggest that agriculture is undergoing a fourth revolution triggered by the exponentially increasing use of information and communication technology (ICT) where traditional agriculture is transforming into smart agriculture due to the prominence of the networks and technologies. Autonomous, robotic vehicles have been developed for farming purposes, such as mechanical weeding, application of fertilizer, or harvesting of fruits. The development of unmanned aerial vehicles with autonomous flight control together with the development of lightweight and powerful hyperspectral snapshot cameras that can be used to calculate biomass development and fertilization status of crops, opens the field for sophisticated farm management advice. Moreover, decision-tree models are available now that allow farmers to differentiate between plant diseases based on optical information. Virtual fence technologies allow cattle herd management based on remote-sensing signals and sensors or actuators attached to the livestock. Taken together, these technical improvements constitute a technical revolution that will generate disruptive changes in agricultural practices. This trend holds for farming not only in developed countries but also in developing countries, where deployments in ICT (e.g., use of mobile phones, access to the Internet) are being adopted at a rapid pace and could become the game-changers in the future (e.g., in the form of seasonal drought forecasts, climate-smart agriculture).Smart farming can make agriculture more profitable for the farmer. Decreasing resource inputs will save the farmer money and labor, and increased reliability of spatially explicit data will reduce risks. Optimal, site-specific weather forecasts, yield projections, and probability maps for diseases and disasters based on a dense network of weather and climate data will allow cultivation of crops in an optimal way. Site-specific information also enables new insurance and business opportunities for the entire value chain, from technology and input suppliers to farmers, processors, and the retail sector in developing and developed societies alike. If all farming-related data are recorded by automated sensors, the time needed for prioritizing the application of resources and for administrative surveillance is decreased. However, although the "Internet of Things," including agricultural machinery, can be used to manage standard farming situations, the farmer still needs to serve as both scientist and watchdog, keeping an eye out for unforeseen situations.

The Editorial Board trusts that the Proceedings of the ISAE 2019 contributes as a rich source of knowledge generated by eminent scientists, policy makers, planners, technologists, and thinkers on the main theme of ISAE 2019 "Networking for smart agriculture and sustainability of bio resources". There will be 65 oral presentations and

26 poster presentations presented at 6 parallel technical sessions under 3 sub-themes namely 1) Networking for smart agriculture, 2) Dedicated Session for the oil palm industry of Sri Lanka, (3) Climate change impacts on fisheries and coastal resources, (4) Production technologies, (5) Food and nutrition and (6) Socioeconomic interventions and agribusiness management. The proceeding is also enriched with the papers based on the keynote speech of the inaugural session by Dr. Herman Brouwer and keynote speeches presented at the 6 technical sessions and the Young Graduates' Forum.

On behalf of the Editorial Board and the Publication Committee, I would like to extend our deepest gratitude to the chief guest, keynote speakers and all authors for their intellectual contribution and commendable collaboration in the process of preparing this proceeding. Proceedings of the ISAE 2019 are a satisfying outcome of a much committed team effort of many including the coordinator of ISAE 2019 and, the members of publication committee and the Editorial Board. Their effort is highly appreciated and acknowledged.

On behalf of the Editorial Board, I would like to extend my best wishes for all participants for a productive and entertaining experience at ISAE 2019.

Prof. Guttila Yugantha Jayasinghe
Editor-in-Chief
Proceedings-ISAE 2019

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Message from the Chief Guest

Honorable Minister of Agriculture, Rural Economic Affairs, Livestock Development, Irrigation and Fisheries and Aquatic Resource Development Mr. P. Harrison

The invitation to participate as the chief-guest in the Ninth International Symposium of Agriculture and Environment 2019 (ISAE-2019) is an honor to my service as the Minister of Agriculture, Rural Economic Affairs, Livestock Development, Irrigation and Fisheries and Aquatic Resource Development and I release this message, with my great pleasure.

Successful adoption and implementation of ICT in the field of agriculture is timely needed since all the technologies are well-developed and user-friendly for any person in different strata of education. Technology, especially ICT, has uplifted the standards of all the sectors such as industry, education, health, transportation, research and management.

Agriculture is the basement of a country on which all the people rich or poor, well-educated or less-educated depend on for their food requirement; for basic three meals or for providing materials for industries such as food-packing, food value-addition, food preservation, tourism or product exportation. On the other hand, the agriculture sector can be supported by the novel technologies in all the other fields including management, engineering, chemistry, transportation, and ICT.

The e-agriculture is the latest trend that the new generation would like to be experienced and utilized. This will be a great power of attraction and retention of the new generation in the agriculture sector since the lifestyle of them is tightly bound with the latest technologies.

I really appreciate the targets of ISAE 2019 that tries to interconnect all the stakeholders in the field of agriculture working on ICT and networking. Planning the roadmap for the future of the ICT and Networking in the agriculture sector and identification of standards of the ICT and Networking for the long-term sustainability are trustworthy efforts for uplifting the agriculture sector for a new e-agricultural era.

While wishing to be a successful event ISAE 2019, I would like to see the beneficial outcome of the implementation of the thoughts of ISAE 2019 for the betterment of island-wide stakeholders.

Message from the Vice Chancellor
University of Ruhuna

The foundation stones of University of Ruhuna are laid on the essence of academic pursuit and excellence. We have successfully worked our way towards our vision "**To be the prime intellectual thrust of the nation**", by strengthening research activities as well as providing high-quality education and community services. Both staff and students take pride in having contributed to the national and international reputation of the University of Ruhuna that has officially acknowledged for the excellence of its teaching, research, and service to the local, national and international communities.

Excellence in any work can be successfully achieved only through utmost dedication, hard work, and determination. With the commitment of highly qualified and efficient staff, the Faculty of Agriculture, University of Ruhuna endeavors dynamically to make a mark in the field of research and development related to the Agriculture and Environment. The Faculty of Agriculture is now, for the 9th consecutive year, planning to congregate the International Symposium on Agriculture and Environment, 2019 (ISAE 2019) under the timely important theme of "Networking for smart agriculture and sustainability of bioresources".

Agriculture is the foundation of developing economies. Sri Lanka needs to ensure a healthy agricultural industry that contributes to the country's gross domestic product, food security, social welfare, job creation, and ecotourism, while adding value to raw materials. Reflecting back through the past years at the ISAE, it is clear that the themes related to sustainability and innovative agriculture play important roles. With the intervention of mechanization, industrialization of various production processes and introduction of chemical fertilizers are plying a leading role in farming. Connectivity and management of the data that are generated through these interventions are now being set to unleash the next revolution in the history of Agriculture and farming, with Smart Farming and Precision agriculture. We have now reached a point where it is impossible not only to collect vast quantities of farming-related data but also to control numerous pieces of equipment or monitor individual animals, in a traditional or conventional manual means. In the global context, a huge and exceedingly growing number of farmers have already started to adopt digital technologies and data-driven innovations. The ISAE 2019 will discuss the integration of smart technologies to Agriculture sector in Sri Lanka considering the influence of numerous innovative technologies to various sectors in agriculture with sustainable utilization and latest trends in bioenergy, biobased technologies and products.

Organizing an International Symposium is always an enormous challenge. I have all the confidence that the Faculty of Agriculture is equipped with dynamic and highly capable staff to hold the ISAE 2019 up to the highest intellectual standards that meet the expectations of international academic and research community. On behalf of the University of Ruhuna, I wish the ISAE 2019 all the very best and urge all participants to move through the inspiration of the various thrust areas of the symposium. I welcome all the international delegates and extend my congratulations to all the authors, the Dean of the Faculty of Agriculture, organizers of the ISAE 2019, and all the contributors. I wish you all the success and a highly productive day!

Snr. Prof. Gamini Senanayake
Vice Chancellor, University of Ruhuna

Message from the Dean
Faculty of Agriculture, University of Ruhuna

It is a great pleasure and honor to send this message as the Dean on behalf of my colleagues who worked tirelessly to organize this symposium amidst many obstacles and challenges. The Faculty of Agriculture, University of Ruhuna has very successfully organized two national and eight international symposia during the past decade and we are committed to raise the standard of this event and live up to the expectations of contributors who selected our symposium to present their research findings.

Our vision is to make ISAE an annual meeting place for scientists and professionals in agricultural, environmental and allied sciences to share their research findings, innovative ideas and forge new collaborations. Agriculture is considered as one of the main polluters of environment and our biggest challenge is to raise the agricultural production to feed the ever increasing human population while protecting the environment.

The broad theme of this year's symposium is *"Networking for smart agriculture and sustainability of bioresources"*; highlighting the need for the integration of ICT solutions to agriculture for enhanced productivity and to ensure prudent use of bioresources to sustain a healthy population on planet earth. With the rapid expansion of ICT and mobile applications in every sphere of our life, there are many opportunities for agriculture sector to integrate these modern technologies to address the issues in accessibility to knowledge and information and to offer solutions for marketing and logistical problems faced by farmers and industry. Various public and private sector institutions and individuals have already embarked on activities of integrating ICT into agriculture, however, they operate independently with limitations. Therefore, a networking platform for all these initiatives would be valuable in sharing technologies and solutions. We also believe that integration of ICT to agriculture would attract young generation to farming with their high dependence on ICT and mobile applications.

Networking in research is pivotal for the advancement of science and technology and hopefully, the presentations done and discussions followed at this symposium would lead to further research and development of technologies and collaborations towards national development. I take this opportunity to express my sincere gratitude to all my colleagues of the organizing committee who devoted their time and energy to make this event a success and I am also grateful to all our sponsors for their generous and valuable support. Finally, I sincerely wish all authors, invited speakers, special guests and participants a productive and pleasant stay at ISAE 2019.

Prof. Sudas D. Wanniarachchi
Dean/Faculty of Agriculture
University of Ruhuna

Message from the Coordinator of the Symposium

It is a privilege to compile this message as the coordinator of the International Symposium on Agriculture and Environment (ISAE), which has evolved to be one of the well-recognized congregation platforms for the professionals in the fields of agriculture and environment. I herewith welcome and thank all the invitees, sponsors, presenters and participants on behalf of the organizing committee.

Since the beginning, the team behind ISAE is committed to develop and provide a conducive environment for the scientists and professionals working on wide range of disciplines to gather, present and discuss various issues in agriculture and environment.

From the very definition of agriculture, it is clear that it is one of the fields which ramifies through all the strata of the society, necessitating an articulate value chain. The logistical and informational gaps between the entities of the value chain could be easily bridged with the intervention of ICT and networking. Various attempts have been made by different working groups to provide ICT solutions and, it appears that they are yet to be reached to the far ends of the system. The selected theme being the "Networking for smart agriculture and sustainability of bioresources" this year ISAE 2019 attempts to provide a platform to the stakeholders in the agriculture sector of the country to gather and discuss about the avenues of working together to establish the roadmap for the development of ICT and networking in the agriculture sector.

Two other timely important topics, the problems and the prospects of the oil palm industry and the climate change impacts on fisheries and coastal resources, will also be discussed through two dedicated sessions with the participation of the stakeholders including scientists, policy makers, concerned groups and industries etc. The other parallel technical sessions are expected to generate discussions stretching across the fields of technology, socioeconomic interventions and food and nutrition.

The organizing committee strives to make your time at the symposium fruitful and comfortable as much as possible. While apologizing for any inconveniences, I wish a productive time to all the contributors to the ISAE 2019. Also we hope that you all will continue to be connected to ISAE in the future.

Dr. Chamila Wijekoon
Coordinator, ISAE 2019

Keynote Speech of the Inaugural Session

Stakeholder Networking for Smart Agriculture: The Way Forward for the Agricultural Sector in Sri Lanka through Multi-Stakeholder Partnerships

Herman Brouwer
Senior Advisor, Wageningen Center for Development Innovation (WCDI), Wageningen University & Research, The Netherlands.

What would agriculture look like if it were really connected, collaborative, and working for everyone?

Food systems in Sri Lanka are under increasing pressure. Productivity is low, pollution of soil and water due to agriculture is high, malnutrition levels continue to be high (FAO/SOFI 2018), and resilience to climate change needs to be improved. As if these challenges are not enough - food systems do not work well for everybody, particularly for vulnerable groups. I will argue that multi-stakeholder partnerships offer a way to make food systems more resilient, both in terms of social, ecological and economical outcomes.

Dealing with these challenges is not unique for Sri Lanka. Lessons from other countries suggest that concerted efforts from all stakeholders are required, based on a thorough understanding of the dynamics of the food system. Yet, the field of stakeholders is fragmented and uncoordinated, unable to maximize the use of resources (land, water, farmers, crops, technology, investment, public policy, entrepreneurship, academia) for better outcomes of these food systems.

An important set of drivers for transformation in agriculture and food are ICT related. There is a new wave of novel technology applications that companies are developing to address food systems challenges. These innovations have attracted more than $14 billion in investments in 1,000 start-ups since 2010, mostly in developed countries (WEF, 2018). They fall into three broad categories of application: (i) GIS related technology; (ii) plant production technology; and (iii) agricultural advisory technology that puts smallholder farmers firmly in the driving seat. Examples will be shared from Wageningen University & Research scientists who are developing these technologies worldwide, with partners.

Science supports the idea that cooperation eventually yields more results than competition (eg. Stewart, 2014). However, collaboration does not come naturally for most stakeholders – it is not just a matter of having the right technology in place. But given the challenges of our time, it is evident that not one stakeholder is able to tackle these challenges alone. Better networks and coordination can improve the performance of the agricultural innovation system (AIS), which is an essential basis for a sustainable and inclusive food system. This keynote will address how such a networked agriculture can be promoted. In doing so, pointers are given for further discussion during ISAE 2019 symposium to make agriculture work better for everyone.

PAPER INDEX

NETWORKING FOR SMART AGRICULTURE

OIL PALM INDUSTRY

CLIMATE CHANGE IMPACTS ON FISHERIES AND COASTAL RESOURCES

PRODUCTION TECHNOLOGIES

FOOD AND NUTRITION

SOCIO-ECONOMIC INTERVENTIONS AND AGRIBUSINESS MANAGEMENT

Networking for Smart Agriculture

Networking for Smart Agriculture - the Plenary Session of ISAE 2019

Session objective:
Strengthen the process of building the road map to streamline the future developments in the ICT applications in the agriculture sector of the country through creating mutually rewarding and beneficial linkages among the stakeholders.

Specific objectives

- Provide a platform for the working groups in the ICT and networking aspects of the agriculture sector to meet each other; create mutually rewarding linkages and a network among the members
- Identify the avenues for collaborations among institutes, working groups and individuals
- Identify the standards to be used in building ICT and networking solutions (software development/ administrative aspects) to improve the integration of the functionality of related solutions
- Identification of the real needs of the agriculture sector for ICT solutions (eg. from farmers' perspective, traders' perspective, ICT service provider's perspective)
- Evaluate the role of a steering committee or an association to expedite and strengthen the development and implementation of ICT solutions
- Identify the qualities of a mobile based networking solution for higher functionality, persistence, and acceptance by the users (evaluate the features of a prototype software at the session)

Expected outcomes

- Establish a network among the working groups and the individuals
- Compile a post symposium report summarizing the ideas and suggestions generated at the session to compliment the buildup of the road map
- Evaluation of the progress of the implementation of the outcomes of the session through future ISAE sessions

The articles published under this session were submitted by various working groups, individuals and institutes to share their experiences, views, comments, success stories and expectations along with the constraints they have encountered if any. These articles are expected to be the base for the discussions at the session.

Govi Mithuru – A Mobile Advisory Service for Farmers

Project of Dialog Axiata PLC conducted in collaboration with DFID-UK, GSMA global, CAB International and Department of Agriculture

Abstract

70% of Sri Lanka's population lives in rural areas and their main livelihood is agriculture. Lack of access to timely or relevant information has always been reported as a prominent issue in this sector. Empirically it is shown that the majority of the farmers own a mobile phone, which they largely use only for voice calls. Govi Mithuru (Farmer's Friend or "Ulavar Tholan" in Tamil) is a mobile advisory service for farmers with the theme "Secure Crop and Family Health", created to address the information gap in the sector.

The service is a result of a partnership between the GSMA and Dialog, working with the Department of Agriculture, Ministry of Agriculture and Ministry of Health of the Government of Sri Lanka, facilitated by CABI South Asia, supported by human-centred design expertise and funded by DFID, the UK's international development agency. The project is part of the mAgri Challenge Fund, an initiative by the GSMA targeting improved livelihoods of small holder farmers in African and South Asian countries using mobile services. Dialog is among six operators worldwide who successfully won the challenge fund from among the mobile network operators in the 13 countries eligible for the programme.

To access the service, farmers simply dial 616 from any Dialog mobile phone. For just Rs. 1/- a day (plus taxes). Farmers may listen to voice recordings that provide customized advice on

1. Land preparation
2. Cultivation
3. Harvesting and post-harvest
4. pest and disease Management
5. New technology and agriculture related new inventions
6. Crop planning
7. Price information
8. Improving family nutrition
9. Sustainable agriculture practises and new methods

Govi Mithuru advice is customized for Wet, Dry and Intermediate Zones, supporting all irrigation types. By the end of December, 2018 over 570,000 farmers island wide had registered with the Govi Mithuru service, obtaining advice for cultivating Paddy (rice), Maize (Indian Corn), Potato, Tomato, Brinjal (aubergine), Big Onion, Tea, Chili, Cinnamon, Pepper, Mango, Papaya, Mushroom and more. Paddy remains the most popular crop in Govi Mithuru, with growing interest in the home gardening segment as well.

Govi Mithuru presents a multitude of benefits and value additions to all its stakeholders. For agriculture sector officials, the platform presents the capability to promote strategic crops, and disseminate time-critical information on weather and disease control, plus, insights into upcoming yields and timings. For the officials at the grass-root level, the service allows for better insights and tracking of farmer progress and needs, enabling targeted advice and a focus on vulnerable sections. For farmers, Govi Mithuru provides information on crop security, better profitability, enhanced engagement with officials, and guidance for nurturing a healthy and well-nourished family.

Govi Mithuru has been welcomed by farmers all over Sri Lanka, with exceptional growth in traditionally agricultural areas such as the North Central, Central and Eastern provinces, with users providing independent testimony to the benefits or advantages provided by the platform.

By the independent research carried out by GSMA, it revealed that,

1. 62% of users regularly use the service
2. 90% regular uses report that they have made at least one on-farm change based on advises received from Govi Mithuru service
3. 25% report changes to planting methods
4. 12% report changes to post harvest handling and storage
5. 60% report decreased fertiliser and pesticide use

Dialog Axiata PLC is committed to working towards achieving the SDGs and enhancing the livelihoods of Sri Lankans on a day-to-day basis, by delivering simple yet effective products and solution as mentioned above. By focusing on SDG 1 (No poverty), SDG 4 (Quality Education), SDG 9 (Industry innovation & infrastructure) and SDG 13 (climate action) Dialog aims to contribute to the overall agenda of Sri Lanka's commitment towards achieving global goals while transforming and uplifting the lives of Sri Lankans. Therefore, this service will be opened for other networks from this year onwards. Farmers who use other network connection, can access the service in near future.

Dialog's mobile-based Govi Mithuru agriculture development programme also serves as a case study for global development and regulatory agencies such as DFID and GSMA who keenly follow its progress, to leverage best practices for the expansion of mobile agriculture all over the world. Dialog is privileged to be at the forefront of this global programme, and worked closely with all agencies towards its fruition.

Keywords: Crop management, Livelihood development, Poverty alleviation, SMART Agriculture, SMART advisory service

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Impact of Information Systems in Sri Lanka: Implications in Vegetable Industry

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Abstract

Vegetable industry is a very sensitive sector in Sri Lankan economy. Cultivation for export market, cultivation for local consumption and cultivation for self-consumption are the main motives of the vegetable cultivation in the country. Farmers are the main stakeholders of the industry and they need information regarding cultivation during all the sections of the crop cycle. Accurate information and knowledge required for all the activities associated with crop cycle. Equip with information and knowledge on time about activities of crop cycle is essential for successful and profitable cultivation. Farmers can obtain information and knowledge regarding the cultivation from sources such as government agricultural officers, newspapers, agro business agents, agriculture related web sites, mobile based information systems and agriculture related mobile Apps. Ultimate objectives of the existence of above information and knowledge sources are, reduction of vegetable wastage, minimising price fluctuations, optimisation of vegetable prices and sustainability. Farmers can successfully cultivate vegetables and earn good profits, if these information and knowledge sources become effective for the cultivation. According to findings of published literature and preliminary researches, vegetable farmers face huge frustrations and issues today. Unexpected sudden price fluctuations, price drops, excess stock availability and vegetable wastage have become common scenarios in the industry. There is a problem get highlighted regarding the impact of available information and knowledge sources. According to the "Cobweb theorem", farmers consider previous season prices as the dominant attraction at the time of crop selection. The "Cobweb" theory further mentioned that, when there is a good demand for a vegetable during previous season, the "demanded commodity" will be selected by large number of farmers for cultivation. As a result of common crop selection, there will be high supply during harvesting period and price become very low due to excess stocks. Set of farmers who face financial difficulties due to price drops will leave from the cultivation, and there will be a short supply during coming season. The short supply creates good demand and high price situation. It will be an attraction for another set of farmers to cultivate the particular crop during next season and it will be occurred as a cycle. The preliminary study identified that, price fluctuation pattern of vegetable market in Sri Lanka behaves according to the "Cobweb theorem". The preliminary study observes that, extend of cultivation also fluctuates according to the "Cobweb theorem". Implemented agricultural information and knowledge sources of Sri Lanka expect smooth market behaviour, but still not achieved the same. The research focuses on ICT based agriculture information and knowledge sources. Reduce stock wastage, control price fluctuations and trim down excess stock arrivals are the main objectives of most of available ICT based information and knowledge sources. The preliminary field research indicated that most of farmers are not aware with the available ICT based information and knowledge sources. Some set of farmers do not interest to use technologies. Unawareness and failures of farmers indicate that the low impact of ICT in the vegetable industry in Sri Lanka. According to international experiences, ICT can be used effectively for vegetable cultivation. The research supposed to conduct an in-depth study regarding failures of achieving objectives of the ICT implications in the vegetable agriculture sector of Sri Lanka. Stakeholders of vegetable industry including farmers, agricultural officers and agriculture related private organizations will be interviewed to identify situations, issues and practical barriers in ICT implications. Agricultural ICT apps and packages will be observed.

Developers of agricultural ICT apps and packagers also get involved to obtain their experiences. The objective of the research is to identify the constrains of ICT implications in the vegetable agriculture sector in Sri Lanka. A set of recommendations for effective implementation of ICT based information and knowledge sources will be delivered for vegetable agriculture sector in Sri Lanka.

Keywords: ICT in Agriculture, Vegetable Industry in Sri Lanka, Vegetable supply and demand, Vegetable excess stocks,

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Prospects for Improving the Cinnamon Industry in Sri Lanka Through ICT: A Case Study in Matara District

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Abstract

Sri Lanka accounts for over 80% of the global trade of true cinnamon. In view of its industrial applications and medicinal properties, there is growing demand for true cinnamon in the world. However, the average yield of cinnamon (*Cinnamomum zeylanicum Blume*) in Sri Lanka is only around 250-300 kgha-1year-1 as against a potential yield of more than 1,000 kgha-1year-1 under good management. Besides, the total annual production is only around 22,000 Mt of which over 60% is exported. Major drawbacks of cinnamon industry are low productivity and quality, poor value addition, lack of market information, small holding size, poor accessibility and inadequate and unsatisfactory extension service. However, ICT can be used as an effective tool in addressing the above issues. Many developing countries use ICT assisting to improve yield and quality for agricultural crops as well as giving precise, timely, relevant information and services to the farmers at a decreased cost. Therefore, a questionnaire-based study was carried out to ascertain the usage of smart phones by cinnamon growers in some major cinnamon growing areas in the Matera district, analyse the gaps in the local value chain of cinnamon and determine the gaps that can be effectively addressed through ICT. It involved interviewing the key stakeholders in the local value chain, including 100 cinnamon farmers, peelers, input suppliers, processors, traders, exporters and service providers. Farm families were selected by simple random sampling while purposive sampling was used to select five Extension Officer Ranges and five Divisional Secretariat Divisions. Ci Results showed that nearly 75% of farmers got a yield less than 650 kgha-1year-1 and around 15% of the farmers got a yield less than 300 kgha-1year-1. Low yield was mainly due to poor management, use of unsuitable lands, non-adoption of recommended agro-technology, poor accessibility due to majority of holdings (nearly 60%) situated in interior side, large number of small holdings (88%), unsatisfactory extension service and lack of weather and market information. Ninety one percent of the farmers used mobile phones and 32% of them used smart phones while 22% had Wi-Fi facility. Around 90% of the stakeholders expressed keen interest to receive relevant information related to weather, agro-technology, support services, market information etc. on a mobile platform. Therefore, ICT enabled m- platform shows great promise in improving yield, quality and profitability of cinnamon. A model for and functions of the proposed integrated mobile application are presented and discussed. This application will prove important in addressing the gaps in the local cinnamon value chain, thereby will contribute to enhancing the cinnamon industry in Sri Lanka.

Keywords: Cinnamon, ICT, Mobile phones, m-platform , Value chain

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Potential for the ICT-based Traceability Applications in Agriculture & Fisheries Value Chains and the Need of Smallholder Inclusion

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Abstract

It is a widely known fact that the agriculture and the fisheries are highly fragmented sectors having diverse range of actors in the respective Value Chains which rely on numerous sources of inputs. Modern agriculture and fisheries have been highly knowledge-intensive and increasingly been information driven. Most of the present-day knowledge consumers demand for verifiable evidence of food product quality and safety. Traceability has been recognized as an information-based, preventive strategy of ensuring food product quality and safety which ultimately allows actors to trace-back or trace-forward the point in the value chain where their current concern lies. Small holder operators dominate the agriculture and fisheries sectors in Sri Lanka. Without ensuring their effective participation, the expectation of overall performance improvements in the respective value chains would not be realistic. However, the major problem is the lower affordability of the Small Holders to the facility of Traceability as individuals although it potentially brings more benefits. Considering all the potential benefits of Traceability Applications, especially such as the ability of lowering the transactional costs through improved communication, actor integration and accountability, improvements in the resource use as well as operational efficiencies, increase in consumer satisfaction, increase in economic benefits, and many other, the Government of Sri Lanka in collaboration with other stakeholders such as investors, Non-Government Agencies, and Donors can provide support for establishing required Traceability Infrastructures of inter-operable nature giving the special attention to the Small Holder Operators who cannot afford especially the initial fixed costs. In this specific endeavour, networking of Small Holder Operators as registered entities, developing Public-Private-Producer Partnerships would play active roles.

Keywords: Agriculture, Fisheries, Small holders, Traceability, Value chains

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Application of ICT in the Agriculture domain

W. Channa Dewamitta

Software developer, Agriculture Department, Southern Province
Managing Director, LinDew Solutions (Pvt.) Ltd.

Our experience in developing application software for the Department of Agriculture – Southern Province has led to the following problem areas and/or findings that needs to be addressed if the solutions are to be practical, sustainable and interconnected.

We have identified the problem to be of two-fold as

1. **Forming the future** - How and what needs to be done to ensure that any development is inter-connectible, void of redundant data and processes, as per a published standard, etc.

   What needs to be done;

   a. Establish standards that the stake holders should adhere to in developing apps/applications.
   b. Have the standards published in a web portal that is easily accessible to any stake holder.
   c. May be to have a stake holder registration process so as to ensure the stakeholders follow the standards.
   d. Be the standards-auditor of the domain and have a mechanism to provide standards-auditing as a service.

2. **Taming the present** - How can we bring the currently available software solutions to be inter-connected and shareable encompassing data shareability, process shareability and application shareability.

   What needs to be done;

   a. Establish a mechanism to inventories the current situation.
   b. Make available a categorized inventory of current applications such as, in-use, done but not in use, planned to do, etc.
   c. The inventory should have the attributes such as features, reusability, applicability and adaptability in other areas (Not application areas but administrative areas).
   d. Develop a mechanism on how to integrate what-is-in-use.

We see that we need a common body/organization that could do the following.

1. Being the official primary-resource/controller of the Agri-domain development.
2. Identify the external domains that are directly influential on Agri-domain.
3. Have a more interactive and proactive relationship with controlling authorities of development of the above external domains.

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An E-Agriculture Advisory and Monitoring System to Empower Farmers in Managing Rice Pests and Diseases in Sri Lanka

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Abstract

An E-Agriculture advisory and monitoring system was developed aiming to enable rice farmers in Sri Lanka to receive instructions on correct identification and recommended solutions for their pest and disease problems of rice in time and, to facilitate relevant authorities for monitoring of pest and disease incidents to identify potential outbreaks.

Many farmers are not competent to identify pests and diseases related issues and decide the correct management practices themselves. They expect the assistance of the field officers of government agriculture extension services for this purpose. However, lack of officers and the knowledge gaps that exist among them hinder the achieving of these expectations.

The system developed is composed of a web application and a mobile application called "*Govi Vedaduru*", compatible with Android 4.0+ version. The mobile application was developed to provide an advisory service through smart phones enabling the farmers to obtain expert guidance from the Rice Research Stations of Department of Agriculture in identifying their field problems and recommend remedial measures to follow. A user-friendly mobile interface was designed in local languages (initially Sinhala) to upload maximum of five images and information about the pest and disease problems by the farmer. Experts access individual incidents, analyze the problem through the web application and make recommendations allowing farmers to receive full advice in Sinhala language through the smart device. Data analysis and reporting module was developed to display classified incidents of pests and diseases. The system was initially deployed in selected five areas (*yaya*) of rice cultivation representing two agro-ecological zones in the Galle district of Sri Lanka in minor season (*Yala*) of 2017, as a pilot project and 60 farmers were registered to the system. During the period of June to October 2017, 19 inquiries on pest and diseases were received and correctly identified and solutions in Sinhala language were sent back to the farmer accounts.

In Galle district, 33 "*Govivedaduru*" accounts were created to represent all 33 Agrarian Service Centre areas and usernames and passwords were given to the Agri. Development Officers in the relevant area during maha 2018/19 to upload farmer field problems to the system. Apart from the farmer user accounts in Galle district, these 33 Agrarian Service Centre (ASC) accounts are expected to monitor the pest and diseases in the district and convey the advisory message for pest/disease problem to the relevant farmer. Problem of getting involved with this advisory & surveillance system by the farmer due to the unavailability of smart phones with them can be solved by this approach to some extent.

The "*Govi Vedaduru*" mobile and web application was designed to the whole 25 districts and hence, this application can be implemented island-wide. However, language of "*Govi Vedaduru*" mobile application should be translated to Tamil language to extend it to Tamil speaking areas.

Chat facility and news facilities are to be included for further improvements of the system to reduce the gap between farmer and agriculture authorities.

Keywords: E-Agriculture & advisory, Mobile and smart computing, Pest and disease monitoring

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Practical Concerns Encountered in Disseminating and Promoting Farmer-supportive Virtual and IT Based Solutions

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Sri Lanka, known as an agriculture-based country, which is blessed to have a range of diverse agro ecological zones, and still performing below the potentials where, the agriculture sector accounts only for 8% of the GDP, while 25% of its population directly engaged in Agriculture. When compared to other countries in the region, Sri Lankan agro-enterprises are lagging behind due to the poor utilization of technology. Use of mobile and IT based solutions will play a key role in future agriculture developments and Sri Lanka needs to focus on these soft solutions to have a fast development in the agriculture.

When assessing the current issues in the agricultural sector in Sri Lanka, we recognize the inability of farmers to obtain a fair value for their produce, encounter heavy post-harvest losses, extended value chain between farmer and the consumer, skewed information flow etc., as major issues in the value chain. We at Croptronix (Pvt.) Ltd. have launched the "Govipola mobile App.", to support and resolve such issues. While we are promoting the concept among the farmers, we found that inadequacies in disseminating and promoting IT based technologies among the stakeholders play a key role.

IT and mobile based solutions are supporting the farmer markets, price awareness as well as trading tools in several technologically advanced countries. India is a good example of using IT and mobile Apps for supporting their farmers, with better market concepts. Smartphone has resolved their issues in agriculture markets and the information dissemination, and it is found to be a prospective solution to overcome the agrarian issues of Sri Lanka.

Rural farmers' engagement in mobile applications is significantly lower than the urban populations, which creates a gap in promoting software solutions towards their marketing issues. As per the discussions had with random farmers, it was found that, though majority of the farmer families have smart phones, not even one of the family members, use it to acquire agriculture information, packages of practices or upcoming trends. Awareness gap plays a key role in optimizing the use of IT based technology solutions. If the farmer is aware that the use of IT and software-based technologies can bring better outcomes in their livelihood, they tend to adhere, within a short period of time. According to farmers, they wish to know the ways and means of using modern technological solutions, if they can have a fair price at the harvesting time. Buyers are also interested to reach the farmers with technological solutions, yet, they find that these technologies are distant from them. This requirement of awareness must be addressed with the proper extension services with government institutes and organizations, directly responsible for agriculture. When the farmer or buyer is willing to find better markets and, they are aware of the potential of IT solutions, they should be guided and assisted by the extension services. Different enterprises are supported by specific agencies through their field officers and all the agencies should be coordinated for better results.

Awareness on agriculture IT solutions, among the field officers of the department of agriculture and department of export agriculture also impacts in promoting IT solutions among farmers. They are the catalyst of promoting the use of technologies by the farming communities, as they closely interact with the farmers. Extension officers are a great asset in disseminating technological advancements through farmer-association meetings and regular workshops.

Agricultural field officers use agriculture-based Apps introduced by the government projects and, majority are confident in using them. However, they need to be aware on the available services, benefits and the reliability of those services.

Agricultural concepts or solutions promoted as digital solutions must be frequently and repeatedly injected to the rural communities, as they are new to the technological sphere. At present, the television, radio, and printed media are dominating in their information access, while advertising-hoardings and billboards give a similar impact on new information. Such far-reaching media must be extensively used in awareness campaigns.

Among the youth farmers, who are engaged in agriculture as the major source of income, the information penetration appears to be in good shape. Currently the young and innovative farmers are using social media as well as the market information received through their mobile phones. They are using YouTube for broadening their knowledge on agronomy, future technologies and post-harvest management etc. Therefore, the awareness campaigns targeting young and innovative farmers and other entrepreneurial farmers, would be a better model for the government and the NGO based extension programs. Extension programs also may focus on generating employment opportunities and development loan schemes. As all the agriculture-based areas are covered with proper telecommunication coverage through different service providers, use of IT and other solutions could effectively be promoted to the younger generation who response faster to the digital inclusion.

Therefore, we suggest that the key issue of disseminating and promoting the use of digital solutions across the agriculture sector could be resolved by organizing frequent and coordinated campaigns especially for the youth farmers, using all possible existing extension systems.

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Application of Smart Technologies to Develop Wet Zone Paddy Farming

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Matara, Galle, Colombo, and Gampaha districts cover most of the wet zone paddy lands in Sri Lanka. Land degradation due to invasive plants, poor drainage and water login, high production cost, low productivity, very high labor requirement for cultivation, aging farmer community, and unavailability of appropriate technical tools and equipment are the key issues associated with the paddy farming in these districts. As a result, at present, most of the paddy lands of the southern coastal belt have been abandoned and, it has significantly reduced paddy production of these districts in the last few decades. It is not only a loss of paddy production but it has created various socio economic and environmental problems.

For solving the lowland drainage problem, the Department of Irrigation is spending hundreds of millions of rupees annually and, no adequate return can be seen. Thirteen mega-scale pump houses have been established in Galle and Matara districts, mainly focusing on the paddy farming. However, the cultivated land is much less than the extent of abandoned lands. Also, invasive plants are spreading rapidly. It leads to a high cost of land preparation and less productivity.

Most of the other problems are interconnected to each other. In most of the seasonal farming scheduling meeting (Kanna Meeting) the number of farmers participating are less than the number of officers. Various efforts such as providing financial support have been taken to encourage the farmers. However, those efforts do not show a significant improvement in the extent of land cultivated. Water management is also a huge challenge because small land pockets scattered in a large area are being cultivated. It appears that most of the available tools for farming are also not suitable particularly for the wet zone paddy lands.

It has been observed that it is a challenge to introduce new technological approaches to the farmer community in the upper age levels because they are reluctant to adopt new technologies. On the other hand, present farming approaches do not attract younger generation. It creates many vacuums in various aspects of current agriculture sector though agriculture superseded all other sectors in ancient Sri Lanka.

The approach of the management of these issues is the integration of all the sectors and their functions. There are many organizations who are looking at these issues through their own scope of specialty. Most of these organizations are doing their research and development work on their own rather than connecting with the rest of the system. The solution to overcome these problems is to develop a common platform to integrate all the efforts in a coordinated environment.

Deploying Geographic Information System (GIS) based applications has a high potential to integrate solutions to most of the issues in the system. As the first step, all the spatial data should be brought into single spatial database and publish as a web-based resource. Sothern Province Irrigation Department has already taken a big step in publishing their spatial database under their domain. It will allow potential users to look at the resources in a broader view.

The next step is to introduce different technological advancements to the farming activities which can draw the younger generation to the paddy field. The path to the deployment of smart technologies would definitely be barricaded with various limitations that should be overcome.

Some of the concepts which we expect to implement based on the integrated GIS database already developed and a monitoring system are parachute planting, crop monitoring, invasive plant species identification, river monitoring and flood warning and irrigation system monitoring and controlling.

We are opened for collaborations from the other working groups or institutes working towards uplifting the agriculture in the country.

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ICT Solutions for the Agriculture Sector of Sri Lanka: Potential Target Groups and Strategies to Inject into the System

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There is no dispute on the fact that the agriculture sector of the country should march forward abreast of emerging technologies and the global trends. Introducing and promoting products and services based on Information and Communication Technology (ICT) is a remedy to uplift the standards and productivity of the agricultural sector. Numbers of attempts have been made by varying individuals, working groups and organizations by introducing ICT solutions to the agricultural sector in Sri Lanka. However, due to the lack of communication between aforementioned parties and the absence of well-defined standards, the occurrence of repetition of the same project, partially build projects, or abandoned projects is unavoidable. Moreover, the penetrations of these systems into the 27% of the population engaged in the agricultural sector appear to be limited mainly due to two factors: 1) In most cases, there is no direct reward to the user and 2) low degree of trust on the product, the technology, the provider of the product or the technology, or the mode of conveyance of the product or the technology to the end user. Any product that does not overcome the above limitations will not penetrate into the target segment of the community, even with adequate awareness campaigns. Therefore, we find that the strategies adopted in penetrating these solutions should be selected strategically and meticulously. Through this write-up, we wish to share our thoughts on the prospects of injecting ICT solutions into the agriculture of the country.

Selecting the target groups

In most of the discussions regarding the development of the ICT and networking solutions, farmers are the focal point while the market side lies on the other end. Some solutions such as advisory services focus on the extension officers. It is our opinion that, before the farmers are drawn to the ICT solutions, the middle level personnel such as extension officers and the market middlemen should be drawn in. Main reason is that they possess the technical knowhow to use the solutions and has the access to the communication media than farmers. Further, they interact with the farmers than anyone else in the system and, the chances of the solution being gradually transferred to the farmers over the time are high.

Give-away than receiving at the early stages (focusing on extension level personnel)

At the early stages of the system development, the incentives for using the system should be focused. The solution should provide certain essential services at hand. For example, applying leave from duty, the delivery of monthly salary slip, meeting schedules and facilities for excuses can be given. These services would build a bond between the system and the users and, the system becomes indispensable component in their day-to-day life. The rest of the features can then be introduced gradually.

Rewards for using the system (focusing on extension level personnel and other government officers)

The usage data of the system could be used to assign points for the awards, career progression and so forth. For instance, the number of advisory/consultation sessions conducted, number of issues raised in the forums, number of advisory services sought can be taken.

Give a chance to build a name in the sector

It is by nature that people tend to build a name for them among the peers or the society. Provide a chance in the system to earn reward points that are openly visible to the rest of the users in the system. The users would definitely turn to the people with higher ratings (E.g. Seller rating systems in online markets). There could be fake personalities at the beginning and, the users will decide their fate over the time.

Further studies on the psychological aspects of the local users

Most of the application development environments use the pre-built components in system development. For example, the icons in interfaces, how the system is launched, color combinations and so forth. In-detailed studies should be conducted to evaluate the aspirations of the local users and their cultural and social background.

Kiosks to deliver services

Fool-proof, attractive and user-friendly Kiosks placed in farmer gathering places such as farmer community meeting places, office of the agricultural extension officers, farmer markets and hangouts *etc.,* could enable the farmers to explore it as groups rather than individuals. The programs delivered through the unit could be articulately developed to attract the users to the unit on regular basis.

Use a reputed channel as the mode of conveying the product

Reputation of any product can be reinforced by selecting a correct reputed marketing channel. This will allow the product to penetrate rapidly into the target segment with low promotional cost. In the case of ICT based applications, integration with the telecommunication sector or reputed farming equipment distributor could open a trusted mode of conveying the product or the technology.

Accelerating Sri Lankan Agriculture and Enhancing Crop Quality Through Affordable Protected and Automated Agriculture Kits

Project of Dialog Axiata PLC conducted in collaboration with University of Moratuwa and University of Ruhuna

Abstract

Smallholder-agriculture dominates rural Sri Lanka, home to 80% of the population. Agriculture employs 33% of the workforce and utilizes 44% of the land, yet contributing only 9% to the GDP. Being unable to invest, poor smallholders loath to risk unfamiliar new technologies, meaning low productivity and low returns. Research shows that the Sri Lankan agriculture sector is less efficient than comparable countries.

We are marching towards a food crisis due to the rapid ageing of the farming population, unattractiveness of the farming career to the youth, conversion of fertile land to non-agricultural uses, water depletion and land degradation, harvest losses due to increasingly adverse climatic phenomena, compounding pest and disease damage, high fluctuations in prices and crop diversification issues. Developed countries face similar issues and, their extensive research and development help them to overcome those challenges while better managing their food security.

One of the promising solutions is affordable climate-smart protected agriculture to liberate the smallholders from the tyranny of the weather and seasonality. Research shows a potential 50%-300% yield increase through environment-controlled agriculture. Under the current partnership with the University of Ruhuna, Dialog is building a crop parameter related knowledge base required for protected agriculture as well as conducting field testing to test the data in field conditions. Low cost sensors and actuator nodes are developed through a partnership with University of Moratuwa.

Main project components:

- Developing the knowledge base for local crop recommendations and agroecological zones
- Develop necessary materials and knowledge for farmer training on new practices
- Developing sensor and actuator kits that are fit-for-need and conditions, at one-tenth or below the current market price
- A data and knowledge management system on cloud
- Advisory content for crop managing and maintaining

Technology Used:

IoT (Internet of Things) will connect sensors and actuators while remotely controlling and monitoring the activities, with a monitoring panel accessible via smart phone. Further, agriculture know-how for regular operation (i.e. fertilizer application, water management, assessing growth and pest and disease identification) will be available at farmer's fingertips using mobile technology. Being cloud-connected, real-time roll-outs of rapid updates or interventions to respond to short-term phenomena in agricultural operations will potentially have a national level significance.

Keywords: IoT, Cloud-connected, Smart phones, m-platform

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Oil Palm Industry

Message from the Chairperson - Oil Palm Industry Session

Oil Palm (*Elaeis guineensis Jacq*.) originated in the tropical rain forest of West Africa. However, because of its economic importance as a high-yielding source of edible oil, oil palm is presently grown as a plantation crop in many countries of the humid tropics, and it accounts for around 35% of the vegetable oil production in the world. Oil palm produces an average oil yield of 3,000 to 4,000 liters per hectare per annum as against only about 750-1250 litters in coconut, about 600 liters in sunflower and about 450 litters in soybean. Therefore, palm oil is competitively priced against all edible vegetable oils in the world market.

Vegetable oils produced in the Sri Lanka meet less than half of the national requirement. Therefore, palm oil is imported to meet the domestic need, which has increased substantially over the past several years. For instance, the import of palm oil stood at only around 15 million kg in 2010 costing LKR 1,469 million, but it has increased to almost 170 million kg in 2015 costing over LKR 19 billion. In the circumstances, there is heightened interest in the cultivation of oil palm in the country. Presently, several regional plantation companies are engaged in the cultivation of this crop, which amounts to around 10,000 ha. It is proposed to expand its cultivation up to 25,000 ha in the next ten years.

However, there is growing concern about the increased import of palm oil on the coconut industry and the expansion of the oil palm cultivation on the environment. It is against this background that the Organizing Committee of the ISAE 2019 decided to conduct a plenary session with the participation of the key stakeholders to discuss the challenges, issues and opportunities associated with the cultivation of oil palm. I am confident that the deliberations and reflections on the above aspects will result in positive outcome to the benefit of the country and its people.

Professor Ranjith Senaratne
Chairperson
Oil Palm Industry Session
Faculty of Agriculture, University of Ruhuna,
Sri Lanka

Message from the Coordinator - Oil Palm Industry Session

It is with great pleasure and pride I send this message on the occasion of ISAE 2019 and first parallel session on oil palm industries, organized by the Faculty of Agriculture, University of Ruhuna. The oil palm theme selected for the symposium with the participation of academics, researches and stakeholders is very timely and important.

This oil palm session is a novel to the ISAE 2019 and provides a forum for the researchers to present and debate their findings. Amidst peers, policy makers and implementers so that the findings will be used in country's sustainable oil palm development.

This session portrays the role played by the Faculty of Agriculture, University of Ruhuna in providing facilitation to oil palm industry and policy makers as well as for the implementers to work together towards achieving sustainable development goals. There are 10 oral presentations at the session along with posters. The participation of internationally reputed two personals as keynote speakers as well as paper presenters will increase the imputes of the session and make it an international one.

Also my sincere appreciation goes to organizing committee of the ISAE 2019, Organizers oil palm session and oil palm industry session sponsors for their untiring efforts in ensuring this successful event. I believe that the outcomes of this session will contribute towards making Sri Lanka self-sufficient in edible oil.

I wish all the best.

Dr. I.R. Palihakkara
Coordinator
Oil Palm Industry Session
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Keynote Speech

The Oil Palm Industry: A Dominant Player in the Global Edible Oils and Fats Trade

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Historically, the oil palm (*Elaeisguineensis Jacq*.) existed in wild in West Africa well before it was cultivated. Archaeological evidence discovered in a 5000 year old earthen jar in a tomb near the pyramids in Abydos, Egypt suggests that palm (fruit) oil (PO) has been traded for food and medicinal purposes over a long period of time. Modern international trade in PO commenced at the beginning of the 19th century, although the trading of palm kernels to Europe has been documented as taking place since 1832. During these early years exports of PO to Europe was from West African countries including Nigeria and Zaire. The oil palm was introduced to Malaya by the British 1870 but the exploration and economic potential of the oil palm fruit was not realized until 1917. In more recent years commercial scale planting of the oil palm has been revived in a number of African countries, but two Southeast Asian nations (namely, Indonesia and Malaysia), as the 'adopted' homelands of the oil palm account for approximately 90% of the world's supply of PO.

Although the world's edible oils and fats market has been growing at a steady pace over a long period, a significant and rapid expansion of the industry has taken place in the last decade in particular. For instance, during this short period the world production of plant-based oils - from 100 to 200 million metric tons (MMT) - has doubled. This is a remarkable outcome for any agricultural crop,and is due to the much higher oil yield per hectare of palm cultivations when compared to seed oils. It is also noteworthy that future growth of this sector has been estimated at approximately 4-6% per annum. Rising world population coupled with global income growth are the key factors underpinning increased demand for oils and fats from both the food and non-food sectors. Currently, palm (fruit) oil leads the market with 70 MMT, and along with palm kernel oil (PKO; 8 MMT per annum) accounts for approximately 40% of the global supply of vegetable oils and fats. Soybean oil is the second most widely traded oil with 2018/19 production estimated at 57 MMT followed by brassica varieties (29 MMT). In comparison the production figures for olive and coconut oils (CO) are much lower - 3 and 3.4 MMT, respectively.

Processing of oil palm fruit bunches yield two types of oils. Palm fruit oil - commonly referred to as palm oil, palm olein, super olein - is derived from the mesocarp of the fruitlets,while the palm kernel nut gives rise to palm kernel oil (PKO) which has a very fatty acid composition when compared to PO. In fact both PKO and coconut oil (CO) are rich in saturated fatty acids (>80%) and share similar fatty acid profiles (Table 1). PO on the other hand is a mixture of saturated (50%), monounsaturated (~40%) and polyunsaturated (11%) fatty acids.

The food uses for palm oil involve both liquid palm olein and solid forms in applications as confectionery fats (palm mid-fraction) and solid fats (palm stearins). The mix of fatty acids and complement of antioxidants in palm oil not only make it a stable cooking oil, but also enable its

transformation into margarines and shortenings for bakery uses without the need for hydrogenation. Both palm oil and palm stearin are therefore trans-fatty acid free, and are effective options for the formulation of trans-free products.

Table 1. Fatty acid composition breakdown of major plant-based edible oils

Fatty acid family	**SBO**	**Palm**	**Olive**	**SSO**	**HOSO**	**Canola**	**PKO**	**Coconut**
Saturated	16	50	15	13	8	8	82	92
Monounsaturated	24	39	74	22	80	63	16	6
Polyunsaturated	60	11	10	66	9	31	3.1	1.9
Total ω6 PUFA	52	11	9.4	65	9	22	3.1	1.8
Total ω3 PUFA	8	0.3	0.6	0.5	-	9	-	0.1

PUFA, polyunsaturated fatty acids; SBO, Soybean oil; HOSO, high-oleic sunflower oil; PKO, palm kernel oil.

Indeed, palm oil has experienced good market uptake following the US Food and Drug Administration's (FDA) recently published criteria for zero-trans fat foods (<0.5 g of trans fats per serving). In contrast to palm oil, common vegetable oils high in polyunsaturated fatty acids (soybean, sunflower, corn, cottonseed) do require hydrogenation to improve their oxidative stability and to increase their melting points. This is particularly relevant for the production of salad dressings, margarines, spreads, shortenings and frying fats. Catalytic hydrogenation of polyunsaturated vegetable oils also leads to the isomerization of naturally occurring cis double bonds to the trans form which has now been declared as detrimental to human health.

Palm oil consumption and its impact on plasma lipids and cardiovascular disease outcomes has been an ongoing subject of debate. The recent systematic review and meta-analysis of 51 human feeding trials by Fattore et al.,2014 noted both favourable and unfavourable changes in biomarkers of cardiovascular disease risk following intake of palm oil. All such human studies have utilised liquid oils (palm oil/palm olein) at various levels of fat substitutions ranging from 4-43%.

The ripe oil palm fruit used in the extraction of PO boasts a rich mix of deep colours (maroon, red, orange and yellow) which are indicative of an abundance of natural antioxidants including polyphenols and carotenes - in the fruit flesh and skin. Indeed, palm carotenes (rich in -carotenes) and palm vitamin E enriched in tocotrienols reside in the mesocarp, and are recovered from the extracted crude palm oil. These products are currently available commercially. In contrast to such lipid-soluble compounds present in the oil phase, the waste stream of vegetation liquor that originates in the milling process and extraction of oil has recently been identified as a rich source of water soluble polyphenol compounds (Oil Palm Phenolics; OPP).

There are a number of non-edible uses of palm oil. These include diverse oleochemical applications such as cosmetic and personal care products, soaps, detergents, bioplastics, printing ink, lubricants, as well as uses in the production of palm biodiesel.

Reference

Fattore, E., Bosetti, C., Brighenti, F., Agostoni, C. and Fattore, G., 2014. Palm oil and blood lipid-related markers of cardiovascular disease: a systematic review and meta-analysis of dietary intervention trials. Am J Clin Nutr, 99,pp.1332-1350.

Keynote Speech

Prospects and Importance of Oil Palm Cultivation and Expansion in South Asia

P. Rethinam

Founder and President of Society for Promotion of Oil Palm Research and , Development (SOPOPRAD), Formerly ED,APCC ;Chairman, CDB, GOI; ADG,ICAR; & Director, N.R.C. for Oil Palm, ICAR.

Oil Palm, (*Elaeis guineensis* Jacq) originated in the West Coast of Africa travelled to Asia, planted as ornamental palms in Bogor Botanical Garden in Indonesia formed the parental source and supplied planting materials for the commercial plantations in Indonesia and Malaysia and subsequently in South Asia. These two countries have emerged as first and second places respectively in the global production of palm oil. Palm oil and Palm kernel oil, the two vegetable oils which were insignificant as global vegetable oils sources during 1960 have attained the highest status of vegetable oils and lauric oils respectively. Global vegetable oil production had increased from 16.07 million tons in 1960 to 187.2 million tons in 2017of which palm oil and palm kernel oil made a tremendous increase from 1.24 and 0.42 million tons to 67.9 and 7.2 million tons respectively for the same period. Asia as a whole was dominating in the production of palm oil and palm kernel oil by 87.80 and 88.46 %, respectively during 2017. Despite all bad propaganda against palm oil, it could occupy the prime position pushing soya bean to second place. It is very clear that the growing demand for vegetable oils as edible oil, industrial oil as well as for bio fuel and bio lubricants could be largely met by palm oil in the future also since many of the countries are increasing the area under oil palm cultivation. India too had identified about 1.98 million ha in 18 states under irrigation and achieved about 300,000 ha so for.

By 2050 the global demand will rise by 35% over 2013 demand and may require 250 million tons. It will be a great challenge to meet the demand keeping the situation of limitation in area expansion, rain fed nature of the bulk of the oil seed crops, limited adoption of technologies and non-availability of seeds of high yielding varieties and hybrid, growing population, increased prosperity in living conditions with high income resulting in increase of per capita consumption, growing need for bio fuel and bio lubricants, new applications for energy, chemicals and technical products with a bio based economy.

2. Importance of oil palm

i. Less land more crop

Out of 4.6 billion ha of total agricultural land available globally, 1.3 billion ha. Is arable and out of that 267.1 million ha land is used for oil seeds as on 2013-2014. It is likely to go up in future. During 2015-2016 to 2019-2020 the average land utilization would be 237.0 million ha. Palm oil uses 5.5% of land (18.6 million ha) used by oil seeds but produce 38.27 % of total vegetable oil production, whereas 40% by soya bean, 14% cotton seed 10% sunflower, 13% rape seed and 18% by the other crops together produce 112.10 million tons (61.23%)of oil. Palm oil required least amount of land (0.26 ha) for producing 1 ton of oil. Rape seed required 1.52 ha, sun flower 2.0 ha and soya bean 2.2 ha.

ii. Palm oil utilization

Despite of the facts that negative propaganda is going on against the use of palm oil, palm oil is the largest produced, exported and consumed oil. Nearly 71% of palm oil produced are being utilised for foods (margarine, processed food, chocolate etc.), 24 % as consumer products (cosmetics, detergents and candles etc.,) and 5% for energy (electricity heating, fuels etc.,).

iii. Oil palm for high oil yield

It is a fact that about 250 million ha of annual oilseed crops grown in the world could produce only 61.73 % as on 2017. Domestic demand is increasing every year since oil consumption is income elastic and by 2050 the demand will be 250 million tons. Fast shrinking of agricultural land for food production warrants high value crops of high yielding nature replacing some low value crops. Scope for horizontal expansion is limited due to faster urbanization, industrial growth and population explosion. Oil palm gives the highest oil yield of 4 to 6 MT/ha/year with a global average of 3.20 MT/ha/year which no other known oilseed crop produces. The highest theoretical oil yield of this crop is projected to 18 MT/ha/year, large plantations in Malaysia with advance planting materials is getting 8.0 to 12.0 tons/ha/year and many of the farmers of India had obtained 8.0 tons of oil/ha /year under irrigation.

iv. Oil palm an eco-friendly crop

Oil palm is an eco-friendly crop and adds lot of organic bio mass to the soil for its enrichment, if properly recycled into plantations.

v. Palm Oil for nutrition and health

Palm oil is one of the seventeen edible oils possessing FAO/WHO food standards and declared as wholesome and nutritious edible oil suitable for human consumption. Palm oil is not fully saturated oil. It contains equal amount of saturated and unsaturated fatty acids. It has been a safe and nutritious source of edible oil for healthy humans for thousands of years. Palm oil like all other oils and fats provides 9 kcal of energy per gram compared to 4 kcal each from proteins and carbohydrates. It helps to maintain healthy skin and hair, ensures proper growth and enables body to absorb vitamins. It is rich in vitamin A and E content because of which it can contribute substantially to the nutritional security of the world.

vi. Elevates the socio-economic status of the farmer with its high returns and sustained income generation with the harvest per month for a period from third year to 30 years the economy of Malaysia was changed with the development of oil palm in the country.

vii. High employment generation

Provides opportunity for higher employment generation in the plantations and allied agro-based industries as well which could change the rural life and provide livelihood security to millions.

viii. Palm oil keeps the world economy healthy

Palm Oil supplies 35% of the world's oil needs at the most competitive price. This keeps price low for consumer and industries. The plantation industry drives economic growth. It provides employment opportunities to poorest people and brings in revenue for national development and stability. Oil palm cultivation and palm oil production are highly remunerative activities which help to keep world economy healthy.

xi. Non-conventional energy

Oil palm wastes like empty bunches; leaves, leaf petioles, male inflorescence etc are a good source for the production of non-conventional energy. The fibre and most of the shell produced by the processing mills are used as fuel for the boilers. Even leaf petiole and empty bunches are used to produce bio energy. Considering its positive characteristics and already established wide ranging benefits, it is hardly surprising that palm oil has progressively gained popularity all over the world.

x. Co-generation and alternate source of energy

Oil Palm provides the possibility of co-generation, alternate source of energy, bio-fuels and bio lubricants.

xi. Oil palm is an efficient scrubber of atmospheric CO_2 (100t/ha/year) and as efficient as tropical rain forest.

Oil palm is a prime candidate for storing carbon in the tropical countries like Malaysia and Indonesia, where it is grown and is also eligible for the Clean Development Mechanism (CDM). The annual biomass productivity of oil palm amounts to 50 $t_{dm}.yr^{-1}$ during its 25-year lifespan.

xii. By-product utilization

The leaves of oil palm contain tocopherol and this can be profitably exploited industrially. Fibres from fronds and empty bunches are reconstituted to make materials such as medium density fibre boards and chip boards. Fibres from trunk are transformed into beautiful furniture. The empty bunch can be utilized as media for mushroom cultivation. The mesocarp fibre coming out of the mill is found to have about 10-12 % of oil and that can be extracted through solvent extraction technology. Oil palm trunks, fronds and empty fruit bunch can be used to produce pulp.

xiii. Oil palm helps to balance out carbon emission

While industrial land use generates carbon, Oil palm keeps the land green by contributing up to 21.3 tons of Oxygen per ha into the atmosphere every year. Global carbon storage by oil palm is estimated at 74 Mt C y^{-1} for 12 m ha due to its high annual bio mass productivity and the amount of carbon sequestered by 11 year old oil palm hybrids under irrigated condition ranged between 7.98 and 35.44 T C ha^{-1}. Papua New Guinea and Ivory Coast oil palm hybrids sequestering the highest and lowest carbon content respectively and about 300000 ha of planting in India oil palm seems to be a prime candidate for storing carbon it also eligible for Clean Development Mechanism (CDM).When 2 million ha is going to come under oil palm the eligibility will be much more.

3. Myths and misgivings

I. The general belief is that oil palm needs more water than other irrigated crops like Paddy (Rice), sugarcane, banana etc., and would drain water sources over a period of time. Comparing the water requirements of many irrigated crops proves otherwise. Oil palm requires sufficient irrigation as it is a fast growing crop with high productivity and high biomass production. Insufficient irrigation will reduce the rate of leaf production, affects

flower initiation, sex differentiation, and results in low sex ratio due to production of more male inflorescence, inflorescence abortion and yield reduction.

II. Oil palm is a gross feeder due to high growth rate, biomass production and yield and therefore, demands a balanced and adequate supply of macro, secondary and micro-nutrients for maintaining growth and yield. Large quantities of nutrients are being removed by oil palm. The removal of nutrients by oil palm is comparatively more than that of other plantation crops but it yields more and also return large quantity of biomass.

III. Organic recycling

Oil palm depletes large amount of nutrients from soil as it is a perennial year round yielding crop, but at the same time adds lot of organic matter to the soil which improves the physio-chemical and biological properties of soil. Oil palm leaves, male inflorescence, empty bunches, fibres, shell, mill effluent can be used for organic recycling. A proper recycling of all these wastes can fulfil more than 50 % of nitrogen and potassium requirement and almost complete requirement of micronutrients by the palm.

Recycling of oil palm wastes and regular incorporation of green manures in the plantations definitely adds considerable quantities of nutrients required for oil palm and are able to reduce the dependence on synthetic fertilizers. This will help in the maintenance of the ecological balance and protection of fast deteriorating environment. The soil health is also maintained.

IV. Palm oil bad for health

Palm oil has excellent health attributes, cholesterol free, raise the level of good HDL cholesterol, lower LDL cholesterol, reduce the tendency for blood clot and thereby reducing the risk of heart disease, rich source of beta-carotene, an antioxidant and precursor of vitamin E and tocotrienols. It contains 500-700µg/g of tacoferal, 1000 µg/g of tocotrienols and vitamin E. Carotenoids in red palm oil (RPO) can also serve as powerful antioxidants and anticancer agents. It is good for heart. It also has protective role in cellular aging. The recently introduced Palm Vitae is rich in vitamin E which act as more effective antioxidants in the biological system and may play a protective role in reducing cellular aging, heart disease and cancer.

4. Technology Options

i. To start with only tick shelled duras were planted but after 1960 when sterile Pisifera were identified large number of dura x pisifera combinations known as teneras with thin shell and oil yield planting materials, compact varieties, tissue culture materials with high yield and oil content are available. Inter Specific crosses of O X E are also available.

ii. Crop removal, requirement of fertilizers at various stages based on soil test –leaf nutrient analysis, fertigation, etc., are available. Oil palm leaves, male inflorescence, empty bunches, fibres, shell, mill effluent can be used for organic recycling. A proper recycling of all these wastes can fulfil more than 50 % of nitrogen and potassium requirement and almost complete requirement of micronutrients by the palm.

iii. Weed management in the early stage is very essential. Once the palm grows up and covers the ground exposure area it will be less. Weed management can be done by manual, mechanical, cultural, chemical and biological methods. Growing leguminous cover crops is one of the effective ways to prevent weed growth.

iv. Oil Palm based cropping

Oil palm is planted at 9 m spacing in triangular system. It has a long juvenile period of 2-1/2 to 3 years and farmer has to wait for such period to get income from oil palm. Multiple cropping is defined as the cropping system involving multiple species crop combination, both annual (ginger, turmeric, tuber crops, vegetables, legume, tobacco etc.) and perennial (banana, cocoa, coffee, nutmeg, etc.) crops with an existing stand of perennial crop. In humid tropics, the basic sources of crop production *viz.* solar radiation and water are abundantly available. Their high efficiency can be achieved by adopting multiple cropping systems. The multicropping system generates more biomass, more economic produce, steady and higher income, additional employment opportunities for the farmer's family and meets the diversified needs of the farmer such as food, fruits, vegetables, fodder, fuel etc.

The multiple crop agro-ecosystems are designed in such a way to manipulate to improve production in a sustainable manner. Mixed cropping in oil palm is also possible after 3-4 years of planting. In mature plantation, shade loving and short stature crops can be grown. The crops like Cocoa (*Theobrama cocoa*), Coffee (*Coffea arabica*), Clove (*Engenia caryophyllus)*, and Nutmeg (*Myristica fragran*) are suitable for this purpose.

v. Mixed farming

Mixed farming in oil palm involves establishment of pastures or grasses in oil palm plantation and maintenance of milch animals. This adds organic matter in soil and controls the weed growth. Fodder crops like *Stylosanthes* sp. And elephant grass (*Pennisetum purpureum*) can be grown in mature plantation. They provide sufficient fodder to rear 4-5 buffaloes per hectare.

vi. Mulching with organic wastes

Mulching of oil palm basins is essential to conserve moisture as well as to control weeds. Mulching can be done with dried leaves, male flowers, coconut husk; empty bunches brought from factory, etc. In adult plantations all the cut leaves can be heaped in between two rows of oil palm which can act as mulch. These mulching materials in addition to conserving moisture, maintain soil temperature, add organic matter and nutrients mainly potassium, and improve physical and biological properties of soil.

vii. Pest management in oil palm

Oil Palm like any other palm has the problems of pests. The pests of coconut always find a place in Oil Palm. However, under good management conditions, these problems are minimum and so there is no need to use the insecticides indiscriminately.

Harvesting of fruits at the right maturity is important with respect to yield and quality of palm oil since immature fruits yield less oil and over mature fruits have high FFA. Excessive bruising of the fruit bunches should be avoided during harvest and transport.

viii. Milling technology

Oil palm processing technology has undergone tremendous changes over a period of time as industry started growing on a large scale. The traditional processing of oil palm is a crude country method of extraction of palm oil.

ix. Effect on the environment-rain fall, temperature and carbon absorption

Today most of the palm oil mills are moving towards zero energy concepts to save the environment. Accordingly the machineries required are available in the leading palm oil producing countries like Malaysia and Indonesia. This zero energy concept gives additional benefits such as bio-gas and compost which can be enriched to have a balanced nutrient content.

x. Food and non food uses of palm oil

Palm oil and its other derivatives are today widely used in both edible foods including Oleo foods and non-edible applications all over the world. Palm oil and palm kernel oil have many of the required characteristics suitable for food applications like cooking oil, frying fats, Vanaspati, margarines speciality fats for cooking, cookies, cake mixes, Instant noodles, toffee fats, biscuits etc. Non-food uses like soap, detergents, personal care products, surfactants, lubricants, polymers,paints and surface coating, pharmaceutical products etc.

5. Oil palm in south east asia

Oil Palm expansion and land tenure in several Southeast Asian palm oil producing countries (the Philippines, Thailand, Vietnam and Cambodia) and cross-compares their experiences with the facts and myths, stories and lessons learnt from other palm oil producing countries, more specifically, Indonesia, Malaysia and Papua New Guinea.

Depending on the national legal frameworks and implementing regulations of the aforementioned Asian states, the expansion of the palm oil industry and the planned cultivation of new oil palm plantations have brought about unexpected consequences. It will certainly transform land tenure systems and foster insecurities of subsistence livelihoods, conflicts and resentments, landlessness and evictions, re-arrangements of ownership, management, occupation, exploitation and utilization of land, forest, water and other natural resources.

Investment in oil palm expansion is also being stimulated by import substitution policies in countries currently reliant on global markets for imports of edible oils such as the Philippines, India and Vietnam and for countries hoping to reduce dependence on imported fossil fuels with biodiesel. With the global bio-fuel industry estimated to double between 2007 and 2017, as the fastest growing segment in global commercial agriculture, both Indonesia and Malaysia have introduced policies to develop a bio-diesel industry both as domestic energy source as well as for export and targets producing 6 million tons of palm oil each year. Cambodia's Office of the Council of Ministers has also initiated a bio-energy promotion plan which points strongly to the further expansion of oil palm plantations in the near future.

The palm oil sector worldwide is in a phase of rapid expansion. Palm oil production and the area under oil palm cultivation in South East Asia have been steadily increasing over the last twenty years and further increase can be expected in the future due to rising demand and the promotion of the use of palm oil for biodiesel. Rising global demand for edible oils and biofuels, global trade, escalating commodity prices and surging international investment are among the

main drivers of this expansion. But domestic considerations are also significant. National governments are promoting oil palm to meet rising domestic demand for edible oils, to reduce their countries' dependency on imported fossil fuels and to limit their loss of foreign exchange. Moreover, where the circumstances are favorable, small scale farmers themselves are choosing to plant oil palm as a lucrative crop.

6. Oil palm in Sri Lanka

Sri Lanka having a land area of 6271000 ha with agriculture land of 2740,000ha and forest area of 2063,000ha planned to go for only 20,000 ha under Oil Palm to produce palm Oil to meet domestic demand and to reduce import bill. The first commercial Oil Palm plantation was introduced in 1967 at Nakiyadeniya Estate, Galle District, almost similar time when Malaysia, Indonesia and India. Malaysia and Indonesia went ahead and expanded their cultivation to make history in Palm oil production. India and Sri Lanka were limping. India changed the policy to go for irrigated smallholder's crop in1986 and now about 300, 000 ha had come under oil palm in 11 states. Oil Palm in Sri Lanka was expanded up to about 9,000 ha until the year 2015. "In 2015, Sri Lanka's annual edible oil requirement stood at 160,000 Metric Tons (MT). Conversely, the country produces a total of just 53,000 MT of coconut oil and 18,000 MT of palm oil, leaving a deficit of 89,000 MT in the island's edible oil requirement,. Notably, this data actually excludes all other vegetable and plant based oils, meaning that the countries actual total requirement is even higher". Accordingly, Sri Lanka spent Rs. 20.8 billion on oil and fat imports. Therefore, in 2016, the policy was established to limit the expansion of Oil Palm cultivation only up to 20,000 ha to meet the requirement of the half of the demand in the year 2015, in order not to disturb the coconut oil industry and to minimize the impacts on the other plantation industries by converting their lands to Oil Palm cultivation. RPCs were advised to use abandoned, marginal and unproductive lands to use for the cultivation of oil palm instead of converting productive lands. In this policy, it was allowed any investor to cultivate Oil Palm but the total was limited to 20,000 ha in the country. As on February, 2016, Sri Lanka has 8863 ha under oil palm in seven RPC'S.

Having understood the cost of production of Oil Palm is around Rs. 15 per kg of fresh fruit bunch (FFB) and COP of coconut is around Rs. 15 per nut. While coconut generates Rs. 175,000 per ha per annum, Oil Palm generates Rs. 514,000 /ha / annum(Nugawela,.2017) It is needless to say that for bringing up 20,000 to 30,000ha under oil palm there should not be so much obstacles. Due to urbanization and industrialization, Sri Lanka had lost considerable area under coconut and other crops. No environmentalists or anybody could prevent the conversion of arable land.

7. Solidaridad initiatives for sustainable palm oil

Solidaridad Palm Oil programme runs in various countries across the globe with the engagement of Government and private players in the respective countries. Solidaridad facilitates integrated solutions to solve the sector's challenges. Solidaridad programmes facilitates smallholders support, market transformation and enabing policies. The Asian Sustainable Palm Oil Network (ASPN) is set-up to foster a regional cooperation and strengthen national government initiatives to promote sustainable palm oil production and trade. The platform facilitates coordination and cooperation to enable different stakeholders to contribute to a more environmentally sustainable and equitable palm oil sector. As the demand for sustainably produced palm oil is an essential driver for sustainability and therefore, we also address the market side together with the production. With the various initiative under the SOLIDARIDAD has made with Malaysia,

Indonesia and India, the scope of The Asian Sustainable Palm Oil (ASPN)can be widened and make as a single window for fostering regional cooperation for sustainable and environmental friendly palm oil production and trade in Asia and addressing the issues related to sustainability and environmental issues.

Acknowledgement

I gratefully acknowledge SOLIDARIDAD for proposing me as key note speaker and sponsor my travel to present this paper. I also thank the organizer for giving an opportunity to share my views and also providing all logistic arrangements at Colombo, Sri Lanka.

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Effects of Decanter Cake Type Oil Palm Solid Waste Application on Growth Performance of *Vigna Radiata*

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Abstract

The increased production of biowaste is one of the major problems of the palm oil industry. Among the different types of wastes, palm oil decanter cake (PODC) is a waste type with a potential to be used as an organic fertilizer. However, limited literature was found relating to the effects of PODC on plant growth performance. Thus the aim of this study was to determine the effects of PODC application on growth of *Vigna radiata* (MI 05). PODC type waste was collected from palm oil mill at Nakiadeniya, Galle, Sri Lanka during the month of April. Soil for the experiment was collected from the undisturbed area in the Department of Botany, University of Ruhuna, Sri Lanka (sandy textured soil with the pH value 6.41 ± 0.03). PODC with the pH value of 6.53 ± 0.05, mixed with soil at rates of 0, 10, 20, 30, 40, 50% w/w and certified seeds of *Vigna radiata* (MI 05) were grown for 45 days. Decreasing trends in root length, root and shoot biomass were observed in plants grown in soils with PODC levels above 10% at 30 days of age. Plant death was recorded from the treatment with 40% and 50% w/w PODC levels at the age of 45 days. Plants grown in soil with 10% w/w PODC level had the significantly higher ($p<0.05$) total chlorophyll content, shoot and root biomass compared to control treatment. The experiment was repeated at rates of 0, 2, 4, 6, 8, 10% w/w PODC to find the best level of PODC for plant growth. Plant growth performance was measured at 30 and 60 days of age. Significant($p<0.05$) differences in the plant growth parameters such as shoot height, stem thickness, shoot and root biomass, leaf numbers, leaf area and pod lengths were observed from the treatments with 2% and 4% w/w PODC levels when compared to control at the age of 60 days. Therefore, the 2% to 4% of range was recognized as the best level for PODC to be used as fertilizer in order to increase the plant growth of *V.radiata*. The overall results highlighted that there is an application rate specific effect of PODC on growth of *V.radiata*. Direct application of 2% - 4% w/w PODC enhances plant growth, while the higher level of PODC application may cause plant death or growth inhibition.

Keywords: Fertilizer, Palm oil decanter cake, Plant parameters*, Vigna radiata*

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Effect of Different Murate of Potash Application Rates on Nutrient Status of Soil and Immature Oil Palm Growth

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Abstract
Initial growth of oil palm highly depends on the quality of planting materials, management practices and availability of macro and micro nutrients. Failure in supply of said nutrients badly affects initially the vegetative growth performance and finally the yield. An experiment was initiated to investigate the available nutrient levels on plant growth performance at Devithurai estate, Ethkandura, Sri Lanka. Field trial was conducted with Randomized Completely Block Design under six different K levels (T1=0, T2 =60, T3 =90, T4 =120, T5 =150, T6 =180 of K_2O/Kg/Ha/Yr) and constant levels of N, P, and Mg with four replicates. Soil nutrient levels and plant growth performances were recorded and data were analyzed with Minitab statistical tool. Results revealed that higher the soil K level, plant height was also increased (recorded up to 263 cm) although the recommended soil K level is 0.3 cmol/Kg for the Oil Palm. Remarkably low soil K levels were seen among treatments. This could be due to low Cation Exchange Capacity (CEC) of this soil which is an inherent character of the Dodangoda soil series. It was shown that there were clear increases in number of fronds, female inflorescence and fresh fruit bunches (FFB). This could be attributed to the fact of initial high soil K level in the soil with periodical application of fertilizer treatments to the trial plots. There were very good soil available P levels at the initial stage of the trial. The recommended soil Mg level is 0.3cmol/Kg for Oil Palm. In this trial Mg level is very low irrespectively to the treatments. Results revealed that there was slight improvement in the formation of female inflorescence and FFB in where the soil K was high. It is concluded that the initial soil nutrient levels especially K is playing a significant role in young oil palm growth ($P>0.05$). Therefore periodical application of fertilizer is required for better performance of this crop.

Key words: Available nutrients, Oil palm, Plant growth, Sri Lanka

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A Comparative Study on Gas Exchange Rates of Young Oil Palm, Rubber and Tea Plants Grown Under Greenhouse Conditions

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Abstract

This study was conducted to determine the gas exchange rates and water use efficiency of young oil palm, rubber and tea plants under different soil moisture regimes. All the plants were grown in poly bags in which the size was determined according to the planting density of respective crops. Another set of rubber plants were planted in the bag size recommended for nursery plants. Plants were grown under greenhouse conditions and half the number of plants were provided with adequate irrigation whilst the other plants were watered to the field capacity only at the commencement of study. In watered condition, photosynthetic rate was similar in both rubber and oil palm. It was significantly low in tea. The decline in photosynthetic rates due to moisture stress was relatively high in oil palm and tea when comparing to rubber. Canopy photosynthesis was high in Oil palm because of the high leaf area per palm. Water use efficiency was maintained with increasing moisture stress condition by oil palm and rubber crops. Tea succumbs to moisture stress much earlier than the other crops tested in this study.

Keywords– Gas exchange rates, Oil palm, Water use efficiency

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A Study on Soil Moisture and Root Distribution of Tea, Rubber and Oil Palm Crops at Different Maturity Stages

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Abstract

This study was conducted to compare soil moisture levels and root distribution of tea (*Camellia sinensis*), rubber (*Hevea brasiliensis*) and oil palm (*Elaeis guineensis*) cultivated in wet zone (WL2a) of Sri Lanka. Tea, rubber and oil palm cultivations were selected and soil moisture content and root dry weight were determined for crops (oil palm, rubber and tea), different soil depths (0-10 cm, 10-20 cm and 20-30 cm), maturity stages of crop (6-9 years and 17-20 years), slope of land (00-50cm,100-150cm and 200-250cm) plant and inter row location. The same data were repeatedly taken three times and each data set was taken at four days after a rainfall. In the study the highest mean soil moisture content was recorded in Rubber lands and mean soil moisture content of rubber was significantly different from oil palm and tea. However, mean soil moisture content of both oil palm and tea were not significantly different from each other. Mean root dry weight was significantly different among crop species where the highest mean root dry weight was recorded in oil palm. The mean root dry weights of rubber and tea were not significantly different with each other.

Keywords– Inter-row distance, Oil palm, Root dry weight, Soil moisture content

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Ground Cover and Surface Biodiversity under Tea, Rubber and Oil Palm Crops at Different Maturity Stages

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Abstract

Although it is profitable, there are many views expressed against the cultivation of oil palm by various pressure groups in the country. One such allegation against cultivation of oil palm is the loss of biodiversity leading to soil degradation due to lack of undergrowth. The objective of this study was to identify the surface biodiversity and the ground cover under tea, rubber and oil palm crops at different maturity stages. The study was carried out at Hulandawa Estate, Akuressa (WL2a), Sri Lanka. The quadrat method was used to study the plant species associated in plantation crops on two transact lines. Menhinick's Species Richness Index and Shannon's Diversity Index were used for the Calculation of Ecological Indices. The study revealed that the variability of mean ground cover percentage values among different types of crops studied was considerably less. Further, the spread of ground cover in oil palm and rubber was similar in different transact lines selected for the study. The floral species richness and Shannon's diversity index varied with age of plantations. Species richness and diversity in Fauna were also similar in all crops tested.

Keywords: Biodiversity, Ground cover, Menhinick's species richness index, Shannon's diversity index

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A Comparative Study of Soil Moisture Depletion and Root Growth in Nursery Plants of Oil Palm, Rubber and Tea under Greenhouse Conditions

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Abstract

This study was conducted to find the root growth and soil moisture extraction by Oil palm (*Elaeis guineensis*), Rubber (*Hevea brasiliensis*) and Tea (*Camellia sinensis*) under greenhouse conditions. Test plants were planted in poly bags in which the sizes were determined according to planting densities of these crops. Another set of rubber plants were grown in recommended bag sizes for nursery. Half the numbers of plants were provided with adequate water during the study period whilst the other plants were watered to the saturation only at the commencement of measurements. At commencement of study, highest soil moisture content was observed in tea while lowest in oil palm. In bag sizes determined according to planting density, the percentage soil moisture content depletion rate was the highest in tea followed by oil palm and rubber crops. In 100 g of dry soil, the lowest moisture depletion rate was found in oil palm and lowest root dry weight was found in rubber. Average soil water loss per bag per day and total root dry mass in a bag was the highest in oil palm and the lowest in tea. The estimated soil water loss per hectare of land was the highest in tea and the lowest in oil palm. The lowest total estimated root dry mass per hectare was observed in rubber. The total root dry mass and estimated soil water loss from a hectare of land were not significantly different in oil palm and rubber.

Keywords: Moisture content, Moisture depletion rate, Nursery plants, Planting density, Root dry mass

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Economic Development and Socio-environmental Conflict: A Case Study of Oil Palm Cultivation in Southern Sri Lanka

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Abstract

Oil palm is extending in Sri Lanka about 6000 ha where 67 % is available in Southern Province. Watawala, Namunukula and Elpitiya are three regional plantation companies involved with cultivation. Oil palm has been in existence as a plantation crop in the southern province for more than five decades strengthening the economy of the country and there is hardly any difference between rubber cultivation and oil palm. Despite the similarities of benefits of palm oil and rubber planting on estates, it is a paradox that people in the area oppose only the oil palm plantations. Most of the objections have come up against oil palm from Galle district. Therefore, the study was limited to Galle district and was conducted in the year 2010. Primary data was collected by interviewing people, holding discussions and providing a questionnaire to identify groups. For this purpose, 125 stakeholders were randomly selected. The views and related data of the three main regional plantation companies were taken to consideration while assessing the importance of oil palm cultivation in Galle District. Secondary data consisting of journal articles, newspaper articles and electronic data on oil palm were analyzed. Rainfall data, snake bite related incidents, information on oil palm based accidents, dogs and other animal related data, fertilizer and chemical usage data, affluent disposal methods were collected by consulting veterinary surgeons, government hospitals and other respective institutes in the area. Reviewing the data of other oil palm planting nations in the similar circumstances and their counter arguments too were scrutinized when completing the research. The majority of the concerns addressed were related to the environment. This includes high water absorption, changes in weather patterns, land degradation, deforestation and affluent disposal issues. Some of the social concerns were increased risk of snake bites, higher usage of agrochemicals and fertilizer and skin diseases spread among dogs. Loss of job opportunities for the plantation workers caused the most distress amongst the community. 65.4% of the sample population believes that oil palm cultivation will not have a negative impact on the environment and 65.5% stated that there are no direct benefits from oil palm. The majority (54%) believed that oil palm was not a suitable crop to cultivate mainly due to the myths they have heard. Furthermore, 61% of the sample population agreed that there was insufficient knowledge regarding oil palm cultivation 56% believed that the cultivation of this crop has no impact on the job opportunities. According to the findings, lack of awareness on oil palm cultivation in the area leads unrest of the community.

Keywords: Environmental issues, Oil palm, Stakeholders perception

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Study the Availability of Naturally Dispersed Oil Palm Seedlings in Nakiyadeniya Region

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Abstract

Palm oil consumption is only second to coconut oil in Sri Lanka. It is one of the rapidly expanding equatorial crops in the world. The aim of the study was to find out the availability of naturally germinated oil palm seedlings in Nakiyadeniya region. The objectives of the study were (1) to find out natural seed dispersed density along the roads and water canals (2) identify the main natural seeds dispersal methods in the plantation (3) identify the natural oil palm dispersal problems faced by the outsiders and inside workers of the plantation. The sampling size was 90 for the survey and 700 m distance plots were used for field experiment. Purposive sampling technique for the survey was conducted within three months interval along the water streams and road for randomly selected seven plots. Descriptive data analysis followed by Microsoft Excel 2010 and inferential data analyzed using t-test by Minitab 17 software were undertaken. Majority of outside respondents of (56%) were female and inside only 30% of weeders were female. In both population majority were in 41-50 age group and majority of employer's educational level was below to O/L. Inside respondents of 54% identified as seed dispersed mainly through birds and outside 72% and 68% responders were identified it is due to transportation ways and water canals, respectively. Seedlings density along the water canals has significantly different between inside and outside of the plantation. The oil palm seeds disperse mainly through the water canal and main dispersal methods are water, animals, birds and mechanical methods.

Keywords: Germination, Oil palm, Seed dispersal method

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Study the Plant Species Diversity under Different Maturity Stages of Oil Palm Cultivation

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Abstract

Essentially an edible vegetable oil derived from an African palm tree known as the palm oil. Popular belief is that palm oil is a useful asset due to its versatility and economic impact. However, recently many viewers expressed their criticisms against the oil palm cultivation, highlighting its negative effects on environment. Those criticisms leading to restrict the establishment, expansion and replanting of oil palm cultivation in Sri Lanka. Biodiversity destruction is one of such criticism raised by the viewers. Hence there is an obligatory requirement to conduct research studies to justify those criticisms to develop and expand the oil palm industry in Sri Lanka. The main objective of this study was to identify the plant species diversity in oil palm cultivation at different maturity stages. The experiment was conducted as a field study at Yatalamatta division, Nakiyadeniya oil palm Estate. Six maturity classes were selected from the plantation. Experimental plots, with sized of 1.5m*1.5m each, were selected randomly, using random table. Twenty plots per maturity class were received. The quadrate method was used to study the plant species. Shannon's diversity index and Menhinick's Species Richness Index were used to calculate the diversity according to six maturity stages. Thirty-five different plant species were identified, it indicated a composite of mixed (plants), weeds of broadleaves, grasses, and with a small count of ferns. The growth of broadleaf was more dominant with sixteen species than the grasses with three species and ferns with four species. The plant species richness and Shannon's Diversity Indexes were varied with the age of oil palm plantation. According to the results of the study, species diversity expressed by Shannon's Diversity Index was the highest in mature oil palm plantation (16-20 years – H=2.52) and the lowest in young plantation (8-12 years – H= 1.55).

Keywords: Maturity stages, Menhinick's species richness index, Plant species diversity, Shannon's diversity index,

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Possibility of Replacing Recommended Fertilizer Applications with Palm Oil Mill Effluent Sludge as Organic Fertilizer for Okra and Kangkung Cultivation

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Abstract

Despite high economical return, palm oil mills generate large amount of waste during extraction and purification processes. Wastewater generates through the process considered as Palm Oil Mill Effluents (POME) and it is the most polluted organic residue induces from mills. However, in Sri Lanka open pond systems are used to treat POME to reduce environmental impact generate when raw POME discharged to outside environment. Meanwhile through the treatment process, POME sludge generates at the bottom of ponds and dumping of POME sludge into oil palm fields is practicing. This dumping has created numerous environmental and social issues. POME sludge contains vital elements required for plant growth and development. Effective use of POME as an organic fertilizer was investigated in this experiment. Specific objectives were to find out the most effective quantity of recommended fertilizer mixture to be replaced by POME sludge for both Okra and Kangkung cultivation and find out the characteristics of POME sludge. Experiment was set up according to complete randomized design with five replicates. Six treatments were applied including 100% recommended fertilizer and gradual increasing of POME sludge up to 50%. Growth and yield parameters were measured for both Okra and Kangkung. The pH value of POME sludge was 7.8 while nitrogen, phosphorous and potassium were 2.37%, 1.16% and 0.38%, respectively. Comparatively higher vegetative growth resulted in 50:50 replaced treatment and there was no significant difference among yield parameters of Okra. For Kangkung, leaf area, fresh weight of tender shoots, root length and fresh weight of underground parts indicated significant difference among treatments. Most of the parameters denoted comparatively higher mean values in 70:30 replaced treatment. POME sludge has significant effect on vegetative growth and further research needed to prove the findings.

Keywords: Kangkung, Okra, Organic, POME sludge, Recommended fertilizer

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Stakeholders' Perception on Oil Palm Cultivation: A Case Study in Kegalle District, Sri Lanka

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Abstract

This study was carried out to determine the stakeholders' attitudes towards crop diversification from rubber into oil palm in Kegalle district. The present study was conducted during June (2018) to January (2019) at Panana division in Madeniya Estate, Warakapola by using simple random sampling technique with 35 participants. Pre tested structured questionnaire and water table depth was measured during eight months period using two wells located in oil palm and rubber plantations. According to the data analysis 3% of labours in 20-30 age categories were observed and it was cleared that future of rubber industry has to face severe labour scarcity. On the other hand, participants were not satisfied with the present wages. However, 60% of them satisfied about their job practiced for a long period. The results clearly showed that 100% of participants were aware of oil palm cultivation in the area by rumors which have created an emphatic public opinion against oil palm. Sociological disfavors such as loss of jobs, no added benefits from oil palm, spreading of skin diseases among dogs, increase of snake population and environmental problems including groundwater depletion and biodiversity degradation. Among the participants, 97% were believed that there is an environmental impact on oil palm cultivation. Among the participants, 37% were experienced difficulties faced due to oil palm cultivation in the area. Job satisfaction level of labourers had a significant relationship with education ($p<0.05$). The fluctuation of ground water table in oil palm and rubber plantations were depended on climatic factors. Water table depth decreased during the dry season (September and January) and increased during the wet season (October to December) in both plantations. Based on findings and future prospects of oil palm industry, awareness programs should be arranged with the support of all stakeholders.

Keywords: Crop diversification, Kegalle district, Oil palm, Rubber, Sociological problems

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Potential of Crude Palm Oil for Biodiesel Production in Sri Lanka

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Abstract

Declining global fossil fuel storage due to increasing consumption and associated environmental pollution have created an urge for investigating the production of renewable and environmentally friendly biofuel. Biodiesel can be considered as one of the most perspective alternative fuels since it is a non-toxic and can be produced from different renewable sources through simple cost-effective methods. The choice of a catalyst for the biodiesel transesterification method primarily depends on the quantity of free fatty acid contents of raw materials. This study was aimed to test the potential of biodiesel production from crude palm oil by using base catalyst. Crude palm oil from Palm Oil factory of Watawala Plantation Ltd, Galle, Sri Lanka was tested for free fatty acid (FFA) content. Crude palm oil was pre-treated with NaOH as catalyst and 20% of anhydrous methanol amount according to oil volume was added for transesterification. It was found that FFA value of the oil was 7 mg NaOH/g which is in favorable limits for alkaline transesterification. The biodiesel yield was estimated as 80% of plant oil through base catalyst transesterification. The produced palm oil methyl ester was characterized. The properties were tested as gross calorific value 40.5 MJ/kg (ASTM D 240), density at 15°C of 878 kg/m^3(ASTM D 1298), ash content 0.02% (ASTM D6751) and acid value 0.34mg NaOH/g (D 664). The production cost of biodiesel by base catalyst transesterification was estimated as 791 rupees per liter. All the tested parameters were within the accepted limits of the biodiesel standards thus making it an alternate fuel for compression ignition engines.

Keywords: Biodiesel, Calorific value, Palm oil methyl ester, Transesterification

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Climate Change Impacts on Fisheries and Coastal Resources

Introduction to the Session – Climate Change Impacts on Fisheries and Coastal Resources

Apart from the many issues confronted in securing sustainable small scale fisheries and effective management of the resources in the coastal zone, climate change is now entering the coastal resource governance and management equations as an important variable. Climate change impacts are mostly felt in coastal areas, which are to a great extent, inhabited by fishing populations. Sea level rise has caused loss of landing centers, beach seining sites, fish drying sites, displacement of fishing populations, etc. Food0 chain in marine habitats has been affected with declines in certain species, which have affected fishing landings, production and fishing incomes. Ocean acidification has caused gradual disappearance of shell fish such as mussels and lobsters. Lagoon ecosystems are also being affected by sea water intrusion causing a decline in productivity. Wetlands form another resource highly vulnerable to climate change, with loss of habitats, reduced bio-diversity and reduced ecosystem services. Again, climate change research too is science-biased; sea level rise, increasing temperatures, impacts on mangroves and biodiversity, etc., with little focus on the impact of climate change on the social system; the various strategies adopted by people to cope with climate change and the impact of such strategies on their wellbeing. Among many populations, those living in coastal areas confront the highest climate change risks which have very serious implications on the wellbeing of fishing communities who form the most important coastal stakeholder group.

The NORHED project on climate change has been engaged in number of research activities and has come out with an array of interesting findings, which have important implications for policy, planning and for further research in the field of climate change and the management of the ecosystem and the human system in the coastal zone of Sri Lanka. The current session is devoted to sharing of the findings of this research project and to identify their policy and other implications towards more effective management of the coastal zone, including small scale fisheries.

Today we have achieved great heights in scientific enquiry; research methodology, analytical techniques and modes of knowledge dissemination. However, research is of value only if they contribute to human development, or to put in today's parlance "sustainable development" which encompasses economic, social and environmental dimensions. These goals are achieved through effective governance and management mechanisms, which demands, among other things, inputs from scientific enquiry. Thus, it is the duty of the scientific community to provide policy inputs to the governors and managers who make policy decisions in guiding the process of sustainable development along an economically, socially and environmentally optimal direction.

Dr (Mrs.) Nilantha De Silva
Coordinator of the Session

A Special Session

on

Sharing the research findings of the NORHED Project

on

Incorporating Climate Change into Ecosystem Approaches to Fisheries and Aquaculture Management in Sri Lanka and Vietnam

(SRV 13/0010)

Key Note Speech

by

Dr. Sunimal Jayathunge

Director- Climate Change Secretariat, Ministry of Mahaweli Development and Environment

Sri Lanka

Session Organized by the

NORHED Project Team, University of Ruhuna

Proceedings of this session is published as a separate publication

Edited by

Prof. Oscar Amarasinghe and Dr (Mrs.) Nilantha De Silva

Keynote Speech

Climate Change Impacts on Coastal Agriculture

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Climate change is a reality and this will have major consequences on agricultural production, especially on coastal agricultural production. The coastal areas are more vulnerable since they also have to contend with increasing sea level and salinity issues, together with other climate related events such as floods, heat waves, tropical cyclones and droughts. Crop models for South Asia forecast that the average yield of rice will decline by around 17% due to climate change. Since rice is a staple food in many countries, climate change will obviously impact on food security. Small-scale farmers in low-lying developing countries, such as Bangladesh, are likely to be most affected because of their dependence on agriculture for sustaining their livelihoods.

This presentation will look at some key issues related to climate change in Sri Lanka and neighbouring countries, such as Bangladesh. Case studies from the Jaffna Peninsula region will be presented. The first one looks at the changing pattern of paddy production in Jaffna Peninsula, with paddy land loss over the last 30 years. Land conversion due to civil unrest has been accounted for. The land loss was attributed to changes in salinity levels, especially in the coastal zones. The second case study looks at projected sea level rise and loss of coastal agricultural land in Jaffna Peninsula. RCP 2.6, 4.5, 6.0 and 8.5 scenarios are used to look at extents of inundation as well as areas that can be affected due to higher tides. The impending salinity issues are also discussed. We than look at some case studies from Bangladesh on climate-smart-agriculture and farmers perceptions to climate change and adaptation practices.

Impacts of Climate Change on Recreational Value of Nature Reserves; Exploring the Perceptions of National Tourists Towards Hikkaduwa Marine Reserve in Southern Sri Lanka

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Abstract

Understanding the phenomenon of climate change and its consequences on eco systems would help in resource management and policy development securing a sustainable future. A considerable amount of literature can be found on global climate change but there is a dearth of information on changes in visitation behaviour of tourists under the context of climate change scenarios, especially in the developing nations. Therefore, a pretested structured questionnaire survey was conducted with 68 national tourists to examine their concern and knowledge on climate change in Hikkaduwa Marine Reserve and examined the possible impacts of climate change on the visitation behaviour and tourist's willingness to support for management actions to mitigate climate change consequences. Results indicated that water pollution, resource damage from visitor use, and climate change were the major threats to the Hikkaduwa Marine Reserve. Almost all the respondents agreed that climate change is taking place and the majority of the visitors believed that the climate change occurs due to the anthropogenic activities such as deforestation, fossil fuel burning for electricity, and agriculture activities. Moreover, results revealed that sea level rise is the most significant impact of climate change on Hikkaduwa marine reserve, which would reduce the beach area creating a negative externality on respondent's visitation behaviour to the marine reserve.

Keywords: Anthropogenic impacts, Climate Change scenarios, Implications, Visitation behavior

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Development of a Climate Change Induced Environment Index for Ecotourism Based on Climate Change Scenarios: A Case Study in Rekawa Coastal Wetland of Southern Sri Lanka

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Abstract

Climate acts as a salient factor in tourist decision-making in destination choice, travelling period, and activity planning at the destination. Therefore, the ecotourism industry may be significantly impacted by climate change, and study aims to ascertain this impact by using a climate change environmental index. The study demonstrates a method for developing a site-specific Climate Change Induced Environmental Index (CCIEI), based on Intergovernmental Panel on Climate Change (IPCC) scenarios, when there is a dearth of climate change prediction data. First, we developed two climate change scenarios, one for short-term (2025), and the other for long-term (2050) effects for Rekawa coastal wetland in Southern Sri Lanka. They encompassed three direct climatic variables; temperature, rainfall, and sea-level rise, all of which were based on IPCC predictions. In addition, there were three climate-induced biophysical variables; number of turtle nests, mangrove cover, and beach inundation. The climate change scenarios predict a rise in maximum temperature, from 27 ^{0}C at present to 29 and 29.5 ^{0}C under the two scenarios. They also predict less rainfall and increased sea-level rise, the latter leading to lower number of turtle nests and more beach inundation. Finally, they predict less mangrove cover. The three climate-induced variables are all shown to contribute to tourists' welfare, and they all deteriorated under the two climate change scenarios. Second, we estimated percentage change of scenario attributes from the present situation to the scenario level (i.e. percentage change in temperature, rainfall, sea-level rise, turtle nests, mangrove cover, and beach inundation). Third, as all changes were of the same sign, i.e. a deterioration, we aggregated the changes to give a composite climate change index. For the climate change scenarios in 2025 and 2050, the values of CCIEI were 89 and 115, respectively under non-weighted condition. With the equal weight allocation for each variable, the values of index were 18 and 23, respectively. The CCIEI received the values of 20 and 27, respectively under the allocation of different weights to the scenario attributes when referring to the focus group discussions. Although, there is some subjectivity in scientific methodology regarding the allocation of weights to the climatic and climate-induced biophysical variables, such an index is a useful tool for researchers working on climate change effects in data poor-countries.

Keywords: Climate Change**,** Ecotourism, Environment Index, IPCC

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Identifying and Mapping of Salt-Affected Lands in Welipatanwila and Nonagama Grama Niladhari Divisions of Hambanthota District, Sri Lanka.

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Abstract.
Soil salinity is one of the main environmental problems affecting extensive areas of land in both developed and developing countries. It changes the fertile land to unproductive land, which ultimately results in the economic loss. In Sri Lanka, salinity problems have been reported in the dry and semi-dry zone districts including Hambanthota. Therefore, identification of salt-affected lands and their various salinity levels are important for land use planning and restoration of salt-affected lands. A study was carried out in the Welipatanwila and the Nonagama grama niladhari (GN) divisions situated in Ambalanthota Divisional Secretariat Division in Hambantota district. The main objective of this study was identifying and mapping salt-affected land by using Geographical Information System (GIS). Specific objective was identification and demarcation of soil salinity according to EC and pH measurement, mapping soil salinity levels and pH Levels using GIS techniques. Salt-affected lands were identified and demarcated into different categories according to the salinity levels using GIS. After the sampling was done with an iron auger, Electrical Conductivity and pH of the samples were determined. The Inverse Distance Weighted (IDW) interpolation technique in ArcView 10.1 software was performed to prepare spatial distribution maps. According to the results of EC, the coastal area was highly salinized, where salinity is >16 dsm^{-1}. The salinity levels of 99% of the lands under paddy cultivation were 4-8 $dsm^{-1}$and 8-16 dsm^{-1}, respectively. The total land area of these GN divisions is 5.75km^2. According to the results of pH, percentage of land area with slightly alkaline 0.17%, moderately alkaline 3.65%, strongly alkaline 52.17% and Very strongly alkaline 44.17% have distributed at the soil depth of 0-30cm. According to this information, it is essential to follow proper reclamation methods immediately to reduce the salinity levels before it becomes a severe problem.

Keywords: Electronic Conductivity, GIS, pH, Soil Salinity

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The Community Perspective Towards the Effect of Climate Change Adaptations on Rule-Breaking Incidences by Coastal Stakeholders: A Case Study in Rekawa in Southern Sri Lanka

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Abstract

Sri Lanka is endowed with a long coastline and a diversity of coastal resources which providing livelihoods to thousands of coastal dwellers. Coastal resources are being used by a multitude of stakeholders; marine fishers, lagoon fishers, farmers, tourism stakeholders. As these stakeholder groups have different interests and in achieving their aims, they tend to impose negative externalities on each other as well as on the existing legal patterns which leads to rule breaking incidences. The coastal ecosystem is also heavily subjected to climate change and people's adaptations in coping with climate change also have implications on existing rule breaking incidences. In this context, the study was undertaken, which aimed at identifying the implications of climate change adaptation strategies on rule-breaking incidences. The study was carried out in Rekawa, in Hambantota District of Southern Province in Sri Lanka. The primary data sources consisted of a focus group discussion and a field survey with a structured questionnaire. Focus group discussion was conducted with a sample of 24 purposively selected stakeholders including 6 representatives from each stakeholder group. A sample of 104 households was selected for the field survey with a questionnaire, following the stratified random proportionate sampling method. The study revealed that all stakeholders experienced and observed changes in climatic parameters, and extent of the impacts of these changes on their livelihood activities varied among stakeholder groups. All stakeholder groups adopted strategies to cope with the impacts of changes in climatic parameters while marine fishers and lagoon fishers were highly affected by the impacts of climate change than farmers and tourism stakeholders. The study also revealed that the strategies adopted by stakeholders affected the existing legal systems by generating rule breaking incidences which led to conflicts between stakeholder groups. Further, this study helps to identify the conflict resolution methods to the response of rule-breaking incidences incurred as a result of climate change adaptation strategies.

Keywords: Climate change, Coastal stakeholders, Rule-breaking incidences

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Crop Responses and Adaptation to Environmental Stresses in the Era of Climate Change

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Abstract

'How will we feed the world in the next decades?' is one of the frequently asked questions among the agricultural scientists. The main evolution that will increase the demand for food is a continued rise in the number of people on our planet. While the world's population consists of 7.3 billion people today, the UN projects that the number will increase by 1.2 per cent annually, amounting to 8.5 billion people in 2030 and almost 10 billion people in 2050. Unfortunately, the population growth is high in developing countries that have the least area of arable lands per capita. Although plant scientists are successful in enhancing crop yield, food crisis is still remaining due to lack of advanced technologies. Plants are the major providers of staple foods for human. But as a sessile organism plants cannot avoid environmental adversities. Due to the climate change different adverse environmental factors like salinity, drought, extreme temperatures, toxic metals/metalloids, waterlogging/flooding, ozone etc. are reducing plant productivity significantly. The complex nature of the environment, along with its unpredictable conditions and global climate change, are increasing gradually, which is creating a more adverse situation. Abiotic stress may reduce crop yield up to 70%. The episodes of drought and heat stress is very common now-a-days. In the last couple of years, we have experienced record breaking high temperature. In contrary, both chilling and freezing are common in many temperate countries and also in other part of the world during winter. Some of the toxic metals/metalloids, e.g. cadmium, lead, arsenic etc. are exceeding their allowable limits which are also major concern for crop production and human health as well. Abiotic stresses modify plant metabolism leading to harmful effects on growth, development and productivity which ultimately affect food security. Therefore, understanding the molecular and physiological mechanisms of abiotic stress tolerance and to find the ways that would increase stress tolerance in plants are crucial in agriculture. Recently, scientists have explored the underlying mechanisms of stress-induced damages and the tolerance mechanisms. They also developed various techniques in conferring environmental stress tolerance in plants. Learning from the tolerant plants and transferring these traits to sensitive plants to gain productivity is now a major concern. With the advancement of molecular tools tailoring of stress responsive genes become possible for the development of tolerant genotypes. Some eco-friendly approaches like phytoremediation has also drawn attention to researchers for the mitigation of metal/metalloids-induced damages. It is possible to minimize losses in agricultural production due to abiotic stresses by a judicious blend of knowledge in crop physiology and crop husbandry procedures. Since environmental stress is concerned with multidiscipline like agriculture, plant science, plant breeding, molecular biology, soil science, chemistry and many other field of biological science an integrated approaches with coordinated and sustainable research may attain the goal.

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Production Technologies

Keynote Speech

The "4 per 1000" Initiative: Soils for Food Security and Climate, or how can Agriculture be the Solution!

Paul LUU
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The "4 per 1000: soils for food security and the climate" Initiative launched on 1st December 2015 at COP21, has the goal to help addressing the following three issues:

a) Improvement of the food security by enhancing soil fertility and combating land degradation.
b) Adaptation of agriculture to climate disruption.
c) Mitigation of climate change.

On the basis of facts enhance by international organizations and scientific panels (IPCC, FAO, ITPS, etc.) the aim of the initiative is to improve levels of organic matter and foster carbon sequestration in soils through the implementation of land management methods (agriculture, forestry, soil restoration, etc.) appropriate to local environmental, social and economic conditions.

In summary, in addition to drastic lowering of GHG emissions due to human activities, agriculture and forestry are the most important parts of the solution in terms of climate change mitigation, adaptation to climate change and also contribute to increasing food security, but we need to work on the long term by adopting cultural practices favourable to the storage of C in soils and maintain them.

From a scientific idea was born an international initiative, supported by many stakeholders, recognizing that soils, through carbon sequestration, could be an important part of the solution to climate change.

Recognition of the initiative as one of the main initiatives of the agricultural component of the Global Climate Action Agenda (after the Lima-Paris Agenda for Action) testifies to the priority assigned to the setting of ambitious targets for climate and food security.

The initiative is developing both an action plan and an international research and scientific cooperation program and promotes international (i.e. trans-regional and trans-continental) exchanges of experiences and learnings.

This is a wonderful opportunity to act against land and soil degradation in a win-win approach. The question is now how we move from the concept, to the concrete development at the field level?

The "4 for 1000" Initiative must be translated in the field now by concrete achievements at all scales (practices, projects and policies) to allow to reach results.

To do this, we need support of different kinds: a favourable environment at political, social and economic level, a collective awareness to encourage the consumption of products that meet specifications defined with producers and actors of the value chain committing jointly in the desired direction, and recognition of the work of farmers and foresters in the field, by maintaining and developing the good practices that enable the storage of carbon in soils, limit and avoid erosion and even restore the soil.

On the basis of these elements (policies at the level of countries or regions, the driving force of civil society including economic actors, trust and support for agricultural and forestry producers, and research and scientific cooperation) projects can be developed at large scale based on appropriate practices to meet the challenge of the fight against climate change, via a better overall vitality of soil and land.

Keynote Speech

Distribution and Dynamics of Fukushima-derived Radiocesium in Forest Ecosystems

Masahiro Kobayashi

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Following the Fukushima Daiichi Nuclear Power Plant accident in 2011, a large quantity of radionuclides contaminated a wide area in the northeast region of Japan. Radiocesium (Cs-134, Cs-137), which has a long half-life, was initially trapped primarily in the canopy and litter of forests; over time, it has gradually migrated into mineral soils. Ionic cesium is strongly bound by some clay minerals. Therefore, radiocesium is expected to remain within the surface soil layer after reaching the forest floor without major runoff in forested watersheds. Beginning just after the accident, many researchers have investigated the distribution and dynamics of Fukushima-derived radiocesium. In this presentation, studies conducted mainly by FFPRI researchers will be introduced.

We monitored the inventory and transport of radiocesium within forests in Fukushima and Ibaraki prefectures beginning in 2011. In the first year, more than 50% of radiocesium was intercepted by the canopy and litter layers and remained there. This rate decreased rapidly over the following years. The radiocesium concentrations in tree wood are not too high for use as a building material. However, the radiocesium concentrations in oak wood present a serious problem for mushroom production. Radiocesium concentrations in throughfall and litter leachate rapidly decreased over the first few months and gradually decreased in the following years. In the summer, high concentrations of radiocesium are often observed, along with high concentrations of suspended solids. Following infiltration, the radiocesium concentration in soil water rapidly decreased with depth, demonstrating a strong capacity of clay minerals to bind radiocesium. Dissolved radiocesium concentrations in stream water have been very low since immediately after the accident. Particulate radiocesium concentrations increased markedly during rainfall events, while radiocesium runoff was very limited, even during a typhoon event. In rice production, intensive potassium fertilization has been successfully employed to reduce radiocesium uptake, and the same effect was confirmed in seedlings of Japanese cypress. Decontamination has been widely conducted in contaminated residential and agricultural areas at huge cost, but not in forest areas. To evaluate the long-term impact of radiocesium, it is necessary to continue monitoring and to develop predictive models.

Keynote Speech

Managing Natural Resources for Biodiversity and Sustainable Use of Traditional Medical Herbs

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Abstract

Approximately 10,000 years ago, human harvested wild plant for food, selected wild species to grow from the field which surrounded them, and finally domesticated crops and animals. Cultivated plant species were experienced long-term selections and bred to new cultivars to fulfil the needs of human beings. However, several wild species for traditional medical purposes were under different fates, some species were selected from the wild individually to domesticate and others are still directly collected from the field. In the past years, human activities and extreme climate changes have caused severe declines in wild populations such as habitat changes, threatening the vulnerable species and also including many traditional medical herbs. For example, the Danggui, Angelica sinensis (Oliv.) Diels, is an important Chinese herb but wildly extinct. In this work, we used different case studies to discuss the phytogeographic patterns and genetic diversities of different species which have been affected by human activities. The loss of genetic diversity brings the risk of serious evolutionary consequences which including the adaptations and long-term interactions with other organisms. In this study, we used the population genetics which based on the molecular markers to evaluate the genetic diversity, population differentiation and species divergence. The analysis of multilocus genome-wide markers was conducted with several specific goals: (1) to evaluate the population genetic variation of the remaining wild populations or landrace varieties, (2) to evaluate the spatial grouping and genetic hotspots of the Chinese medical taxa based on the assignment test, (3) to identify distinct genetic units for in situ and ex situ conservation management for sustainable use.

Translocation, Bioaccumulation and Environmental Effects of Graphene Materials in Plants

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Abstract

Graphene is the most important and applied carbon nanomaterials nowadays. Plenty of graphene products are commercially available, including screen, battery, filter and cloth. With the increase of research, production, application and discharge of graphene based products, graphene would enter the environment and induce unwanted toxicity, which requires thorough investigations. Plants are the producer of biogeochemical cycle and provide the fundament of energy and material for the environment. In the past years, we used ^{13}C labelled graphene as the tracer to investigate the translocation, bioaccumulation and environmental effects of graphene in plants. ^{13}C-labled graphene oxide (GO) and reduced GO (RGO) were prepared by arc discharge method, followed by Hummer's method and chemical reduction. ^{13}C-labeled graphene was quantified by isotope ratio mass spectroscopy (IRMS). The results indicated that GO was restricted in the roots of plants and hardly migrated to the stem and leaves. On the other hand, RGO could translocate from roots to stems and leaves. GO was toxic to plant roots, indicated by the inhibited root elongation and the changed structure. The toxicity to root further led to the growth inhibition of whole plants. However, GO did not change the photosynthesis parameters. In contrast, RGO showed much lower toxicity to plant roots. The accumulation of RGO in leaves led to the inhibition of photosynthesis. The ultrastructure of leaves did not change upon the exposure to RGO. In addition, due to the strong interaction of GO and soil, the soil cultivation of plants alleviated the toxic effects of GO comparing to that in water cultivation. The shape and size also regulated the toxicity of GO, where hydroxylated fullerene (spherical and smaller) had no toxicity to plants and migrated easier. Further, the toxicity of GO and RGO to plants was attributed to the oxidative stress in plants.

Keywords: Graphene, Oxidative stress, Photosynthesis, Plant, Stale isotope, Toxicity

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Increase the Legume Production with Sustainable Maize-Legume Intercropping Systems in Sri Lanka

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Abstract

The increased production frequency in same land, yield advantage, increased resource use efficiency and to enhance the sustainability of the system are the major benefits of the intercropping systems. Cereal legume intercropping is the most beneficial commonly practiced intercropping system in Sri Lanka. The objectives of this research were (a) to study the feasibility of legumes cultivation in commercial maize cultivation without affecting to the yield of maize (b) to increase the cultivation extent of legumes in Sri Lanka by increasing land use efficiency (c) to convert commercial mono cropping systems of maize to sustainable maize legumes intercropping systems. The experiment was conducted at grain legumes and oil crops research and development center, Angunakolapelassa ($DL1_b$), Sri Lanka during 2016 yala and 2016/17 *Maha* seasons. The experimental design was Randomized complete block design (RCBD) with 3 replicates. In sole crop treatments, maize was planted with the spacing of 60 cm between row and 30cm between plants. In intercropping treatments, 75 cm was maintained between rows and 30 cm of spacing maintained in between maize plants in this system. In intercropped treatments cowpea (*ANKCP1*), Mungbean (*MI 6*), Groundnut (*Thissa*), Kollu (*ANK BROWN*) and Soy bean (*MISB 1*) were planted in between the two maize rows. Maize crop and all the intercrops were established simultaneously, and the fertilizers were applied according to department of agriculture recommendations of maize. For the legume crop, fertilizers were not applied. The results revealed that there was no significant reduction in maize yield, per cob weight in intercropped treatments compared with the sole crop of maize. Other yield parameters such as 100 seed weight, number of cobs per m^2 area, per plant biomass also are not significantly different with the treatments. It can be concluded that commercial mono-crop maize cultivation systems can be modified into sustainable legume maize intercropping systems by cultivating legumes in between maize rows with the increased spacing from 60cm to 75cm without any yield drop of maize while increasing the legume production additionally.

Keywords: Intercropping, Legumes, Maize, Mono cropping, Sustainability

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Yield Components and Quality Characteristics of Selected Cluster Onion Lines Developed Through Cross Breeding

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Abstract

Newly out cross bred two cluster onion lines were evaluated with four check cluster onion lines/ varieties to evaluate their yield, yield components and quality characteristics for selecting most suitable consumer and farmer friendly line/s for the dry zone of Sri Lanka. The plant breeding program was carried out from 2014 Yala season to 2016/17 Maha season at Grain Legume and Oil Crop Research and Development Centre, Angunakolapelessa. The experiment was conducted according to the recurrent parent selection procedure and progeny selection method was followed to select important characteristics. The experimental design was Randomized Completely Block Design (RCBD) with three replicates. Data were analyzed by using Anova procedure. Based on the study, ANKCLO 2015/1 and ANKCLO 2015/2 (newly bred lines) were large sized bulbs (>2cm diameter) with higher average yields (>16t/ ha) than other check cultivars/ varieties. According to the Essa and Gamea, 2003, bulb shape index of ANKCLO 2015/1 and ANKCLO 2015/2 exhibited "Rhombic" shape. Growth performances of those lines (No. of leaves, plant height, bulb size, no. of bulblets and yield) were significantly different in a positive manner compared to others. Except released varieties, regionally popular varieties has been cultivated. Most popular cluster onion variety among farmers at Thanamalwila area was "Thelulla selection". Minimum number of days taken to maturity, large number of small bulblets/ plant and low yield were the prominent characteristics of "Thelulla selection". Therefore, cluster onion farmers had not the opportunity to earn more income with low yield. That is one of the major issues in that area. While variety Vedalan was taken >70 days, other treatments recorded < 65 days to maturity. More than 400g/ 100 bulbs weight and >20t/ ha yield was recorded in selected two lines. Those values were significantly higher than check varieties of Vedalan, Thelulla Selection, Thinnaweli Red and MICLO 11-4. The identified characteristics of large sized, early maturity and higher yield are the important characteristics for consumers as well as growers too. Similarly, quality parameters had been well performed for the texture and flavor.

Keywords: ANKCLO 2015/1, ANKCLO 2015/2, Cluster onion, Plant breeding, Yield

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Physiological and Growth Attributes of Selected Groundnut (*Arachis hypogaea* L.) Cultivars as Affected by Moisture Stress During the Flowering Stage

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Abstract

Water scarcity is one of the main constrains of agriculture sector development in dry zone of Sri Lanka. Therefore, identifying water efficient crops for dry zone agriculture is timely important. Groundnut is grown in the Batticaloa district to a limited extent where the yield is highly affected by moisture stress especially during '*Yala*' Season. The experiment was carried out to evaluate the impact of moisture stress on yield of three groundnut cultivars (Lanka jumbo, Tissa and Indi) at agronomy farm of the Eastern University, Sri Lanka during '*Yala*'2017. The stress conditions were imposed during the flowering stage. Polyethylene bags (45cm diameter and 42cm height) filled with top soil, red soil and compost 1:1:1 potting mixture was used to grow plants. This experiment was set up according to randomized complete block design with four replications and the treatments were arranged in 3 × 2 factor factorial manner. Moisture stress was imposed for the selected groundnut cultivars for a period of ten days during the flowering stage. The control plants received water once in two days up to field capacity. Measured physiological and growth attributes under moisture stressed condition were significantly($p<0.05$) different between treatments but there were no significant ($p>0.05$) interaction between stress factor and cultivar. The highest relative water content (71.6 %) was obtained in Indi while the lowest (52.2 %) was found in Tissa. The highest chlorophyll a (0.98mgg^{-1}) and chlorophyll b(0.79mgg^{-1}) were recorded in Indi and the lowest (0.47 mgg^{-1} and 0.36 mgg^{-1}) was found in Tissa. Cultivar Indi recorded the highest plant dry weight (127.8 g) while Tissa recorded the lowest (90.9g) under moisture stressed condition. The highest yield (0.8 tha^{-1}) was obtained in Indi and the lowest (0.3 tha^{-1}) was found in Tissa. According to the results, it can be concluded that cultivar Indi performed more efficiently under moisture stress conditions compared to other cultivars hence, could be used in drought prone areas of Batticaloa district.

Keywords: Chlorophyll contents, Groundnut, Moisture stress, Plant dry weight, Relative water content

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Toxicity of Herbicide, Diuron 480g/l SC to Cultivated Rice (*Oryza sativa L.*)

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Abstract

A study was conducted to examine the phytotoxicity of pre-tillage application of Diuron on cultivated rice (*Oryza sativa* L.) crop in order to educate the farmer community in the use of the herbicide. Pot experiments were conducted in a completely randomized design (CRD) with three replicates during the *Yala* season (March-September) in 2015 at the Rice Research and Development Institute (RRDI) at Batalagoda in Sri Lanka. Rice variety Bg300 (three-months age class) was used in this study. Pots (30 cm height x 30 cm diameter) were filled with top soil collected from a paddy field up to the height 28 cm. Diuron was applied using a 16L of knapsack sprayer at the rate of 1800 L/ha to 50% of the pots on the same day while the rest of the pots was treated with water as the control. Thereafter, the experiment was divided into six separate sets (S1-S6) as described below. In each set, three pots each from herbicide-treated and the control were sown with 100 seeds of un-soaked seed paddy at different dates after herbicide treatment; such as, on the same day of herbicide treatment and the first day of the 2nd, 4th, 6th, and 10th week after herbicide treatment. Seed paddy was not pre-soaked to assess the impact of the herbicide treatments on seed germination. All pots were watered until the soil saturation. Germination was tested using the initial number of emerging seedlings, and the seedling counts were taken at weekly intervals until four weeks after sowing (WAS). The percentage seedling survival in herbicide-treated pots was calculated. Data were analyzed performing ANOVA using SAS package. Results revealed that seed germination was not affected by the herbicide treatments. However, in all experimental sets, the percentage seedling survival in the Diuron-treated plots decreased rapidly with time compared to the respective control. In all sets, seedling mortality was observed since 1 WAS with 100% mortality recorded at 2-4 WAS, suggesting the high phytotoxicity of the herbicide to initial growth of rice plants. The phytotoxicity of the herbicide was strongly evident even at 12 WAS. Diuron 480g/L SC at the rate of 1800L/ha, which is recommended as pre-emergence weed control for other field crops is toxic to rice plant. The evidence of seedling mortality reported after 12 weeks after Diuron application reveals that the herbicide persisted in the soil even after 12 weeks from the application. Therefore, Diuron cannot be recommended as a pre-tillage herbicide in paddy cultivation at the rates tested in this study.

Keywords: Herbicide, Phyto-toxicity, Seedling mortality, Seed germination

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In-Vitro Propagation of *Artocarpus altilis* (*Parkinson)* from Shoot Tips Using the Low Cost CSUP Method

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Abstract

Breadfruit (*Artocarpus altilis)* is a traditionally cultivated food crop, propagated using root shoots or root cuttings. The number of root shoots produced by a tree is limited. Therefore, this study was conducted with the objective to optimize *in vitro* establishment of *A.altilis* for rapid propagation. Axillary *s*hoots produced after decapitation of the apical shoot of two breadfruit plants were used as the explants. Recommended dose of fungicide, Deconil chlorotalonil, ™ was sprayed to the mother plants on the previous day. Twenty shoots each from both plants were harvested and placed under running tap water for 2 hours and dipped in 0.001% fungicide, Deconil chlorotalonil™ for three minutes. Ten shoots from each plant were washed in 5% Clorox™ for 10 minutes and 0.1% $HgCl_2$ for 1 minute followed by rinsing with sterilized distilled water for 4-5 times. Other ten shoots of each plant (control) were washed in same approach without 0.1% $HgCl_2$. All explants were established on half strength Murashige & Skoog medium, supplemented with 1 mg/L benzyl amino purine, 1mg/L Kinetin, 250mg/L, Augmentin™ (antibiotic) with 3% sugar at pH 5.8 in culture tubes. Culture medium was sterilized using low cost see sap (CSUP) method as an alternative to the auto claving. After one month of establishment, the explants sterilized with 0.1% mercuric chloride showed 100%and 60% contamination free cultures in plant 2 and plant 1, respectively. All the explants, surface sterilized without mercuric chloride, contaminated and died within 1-2 weeks. Explants from plant 2 only produced new shoots. Browning in culture medium was successfully controlled using weekly sub culturing with 2g/L activated charcoal added to the medium. In conclusion, axillary shoots emerged after decapitation of the *A. atilis* grown *in the* plant house sprayed with Deconil chlorotalonil and surface sterilized with 0.1% mercuric chloride along with 10% Clorox can establish *in vitro* successfully.

Key words: Breadfruit, CSUP method, *In- vitro* propagation, Shoot tip decapitation

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The Effect of *Rhizopus Microsporus* on Seed Germination and Seedling Growth of Seven Crop Species in Sri Lanka

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Abstract

Pathogenic fungal infections on seeds can reduce seed germination and seedling growth, resulting in heavy economic losses. The objective of this study was to determine the effect of soil borne plant pathogenic fungus *Rhizopus microsporus* on seed germination and early seedling growth of seven crop varieties, viz. brinjal (*SM-164),* capsicum (*CA-8*), cucumber (*Kalpitiya white*), okra (*Haritha)*, snake gourd (*TA-2*), spinach (*Yoda*) and tomato (*Rajitha*). The effect on each crop species was observed by inoculating 2 mL of the *R. microsporus* fungal spore suspension (10^5CFU/mL) into 100 surface-sterilized seeds (20 µL droplet on each seed) placed on a sterilized clear plastic box (approximately 20×10×6 cm^3) filled with 1.5 cm of autoclaved silica sand. This setup was replicated four times per each species. The same volume of sterilized distilled water was used as the control. The seeds were incubated in a plant growth chamber at 25 °C and 12/12 hour light/dark cycles for 14 days. Time to reach 50% seed germination (G_{50}), final germination percentage after 14 days and shoot and root lengths of seedlings were measured. Germination percentage data were statistically analyzed using Kruskal-Wallis test, whereas G_{50}, root and shoot length data were analyzed using two sample t-tests. The seed germination percentages of capsicum and brinjal treated with the *R. microsporus* spore inoculation were significantly reduced by 35% and 5%, respectively. The G_{50} was significantly affected in tomato and okra ($P<0.05$). The most prominent effect of *R. microsporus* was evident in shoot and root lengths of the study species. Rotting stems and roots with watery appearance was common in seedlings of all crop species treated with the spore inoculum. The shoot lengths of all the study species were significantly affected by 0.78-4.69 cm ($P<0.05$). The root length of all species except in okra was affected by 0.50-4.29 cm ($P<0.05$). Thus, all the study species were susceptible to *R. microsporus* at seed germination and early seedling establishment stages. Therefore, *R. microsporus* infections can affect the survival and early seedling growth of the tested crop species.

Keywords: Fungal pathogen, Germination, Seedling growth

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Effect of Exogenous Estrogen Treatment on the Gonadal Estrogen Receptor-α Expression in Male Chickens (*Gallus domesticus*)

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Abstract

Sexual differentiation in chickens is controlled by both direct genetic and hormonal mechanisms which can cause genetic sex reversal though manipulations. Estrogen is critical for normal ovarian development and i*n-ovo* estrogen treatment, can feminize genetically male (ZZ) chicken gonads temporarily although a permanent sex reversal could be observed by blocking the Estrogen synthesis in genetic females. The reason for this temporary nature of male to female sex reversal is still unknown. Although *in-ovo* estrogen treatment triggered the Estrogen Receptor-α (ER-α) expression in embryonic gonads, the post hatching gonadal expression of ER-α with age which can possibly affect the temporary nature of this phenomenon has not been studied adequately. Therefore, the aim of the current study was to investigate the post-hatching ER-α expression in left gonads when the exogenous estradiol supply is continuous. Commercial Shaver brown chicken eggs were incubated under standard conditions by giving two *in-ovo* injections, 0.1mg/egg Estradiol Cypionate and same volume of sterile Phosphate Buffered Saline to the treatment and control eggs, respectively. The genetic sexing was done using W chromosome specific sex marker HUR0424. A half of treated male chicks were given with a weekly post-hatching injection of 0.1mg/chick Estradiol Cypionate intra-muscularly (T2) and the rest was raised with no post-hatching injection (T1). Three chicks from each group, including control (C) were sacrificed at 1, 4 and 8 weeks intervals. Total RNA was extracted from the left gonads using the TRIzol method followed by reverse transcription of ER-α gene using a pair of gene specific primers. Following the PCR amplification, the relative quantification of the ER-α expression was performed relative to the expression of reference gene Glyceraldehyde-3-Phosphate Dehydrogenase. Data were analyzed using (SAS) version 9.0. The expression of ER-α showed a significant increase with the age (P<0.0001) and difference among treatments (P<0.0001) where the highest expression was observed at T2 followed by T1. However there was no significant interaction effect observed (P=0.1203) among the groups. Accordingly it can be suggested that although the ER-α expression was induced by exogenous estradiol, there is a male specific mechanism to decrease the triggered ER-α expression, with age.

Keywords: Estradiol cypionate, *Gallus domesticus*, Gonadal estrogen receptor α, sex reversal

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Effect of Vascular Endothelial Growth Factor 165a (VEGF 165a) and Stem Cell Factor (SCF)/KIT-Ligand (KL) on Porcine Primordial Follicles Development In-Vitro.

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Abstract

Initiation of folliculogenesis through the activation of primordial follicle and their development in the female ovary plays a vital role in determining the fertility and reproductive strength of the mammals. Follicle formation and their development in the mammalian ovary is a complex process regulated by the action of the hypothalamic-pituitary-gonad axis is poorly understood. Since the factors that regulate this process are largely unknown, this study was carried out to test the short-term effect of vascular endothelial growth factor 165a (VEGF 165a) and stem cell factor (SCF) also known as KIT-ligand (KL) on porcine primordial follicles development in-vitro. Porcine ovarian cortical stripes were cultured in vitro 5% CO_2 and 95% O_2 under the humidified atmospheric conditions and were treated with different concentrations of VEGF 165a + SCF as follows. VEGF 165a 0.0 ng/ml + SCF 10.0ng/ml (Positive Control), 0.1 ng/ml + SCF 10.0ng/ml, 1.0 ng/ml + SCF 10.0ng/ml and 10.0 ng/ml + SCF 10.0ng/ml). Out of three different dose regimes tested the lowest VEGF concentration, i.e., 0.1ng/ml VEGF + 10ng/ml SCF has shown the highest numbers of viable follicles, (primordial follicles, 57.98%; intermediate follicles, 23.85%; primary follicles, 7.12% and secondary follicles 3.80%) at the end of the culture period. The highest VEGF concentration, i.e.,10ng/ml VEGF + 10ng/ml SCF showed the highest cellular degeneration (68.39%). In conclusion, it is evident that with the low concentrations of VEGF165a along with SCF increase the follicle viability whereas the highest VEGF165a concentrations implicit increased follicle degeneration.

Keywords: Follicle viability, Primordial follicle viability, VEGF, SCF, KIT-ligand

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Present Situation and Opportunities for Better Geographical Equality in Livestock Production in Sri Lanka: An Analysis Based On Gini Coefficient

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Abstract

Local production and consumption of commodities contribute positively towards sustainable development by supporting local economies, minimizing environmental costs associated with transportation and processing, ensuring food safety and quality and reducing waste out-put per unit area. Information about the geographical distribution of different livestock industries are needed to identify opportunities and constraints for the promotion of local production and consumption. This study discusses the present geographical distribution of major livestock industries in Sri Lanka. Gini coefficient (GC) was used to determine the geographical distribution of cow milk, buffalo milk, beef, mutton, chicken egg, and paddy production and, backyard and commercial poultry farms. GC of each item was calculated using district-wise data for the period of 2013-2016.Depending on the availability of data GC of livestock products of India, Thailand, and the USA were calculated for comparison. Top four (NuwaraEliya, Kurunegala, Badulla and Kandy) and ten least producing Districts accounted for 50% and 11% of the national cow milk production, respectively. Sum of the production of 13 Districts accounted for only 10% of the national buffalo milk production. Meanwhile, Trincomalee (12.6%), Hambantota (12.4%), Monaragala (11.6%), Anuradhapura (10.3%) and Ampara (9%) accounted for 52% of the national buffalo milk production. Ampara (34%), Batticaloa (13%) and Anuradhapura (8%) alone contributed 55% of the total beef production. Colombo District reported the highest contribution (62%) to national mutton production. Kurunegala (51%), Puttalam (8%) and Gampaha (5%) contributed 64% to the total egg production. Gini coefficient of cow milk production (0.49) was statistically similar to chicken egg (0.49), buffalo milk (0.57), beef (0.60) and paddy (0.68) production. Meanwhile, GC of mutton production (0.82) was significantly higher than that of cow milk. Indicating the best geographical distribution, backyard (0.25) and commercial poultry (0.25) farms reported significantly lower GC values than other livestock products and paddy. The study concludes that regional distribution of commercial poultry production in Sri Lanka is better than countries such as Germany, The Netherlands, Thailand and India. While admitting the fact that some agro-climatic and demographical factors that could restrict a total equality situation, the paper presents opportunities available for better regional equality of livestock production in Sri Lanka.

Keywords: Gini coefficient, Local, Production, Sustainability

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Effects of Water Hardness on the Survival and Growth Performance of Platy fish (*Xiphophorus maculatus*)

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Abstract

A six-week experiment was conducted to evaluate the effects of calcium hardness on survival and growth performance of platy fish (*Xiphophorus maculatus)*. Three calcium hardness levels; 50 mgl^{-1}, 150 mgl^{-1}, and 250 mgl^{-1} were tested with a control and particular water hardness was maintained by adding $CaCl_2$ $2H_2O$ to the water. Twenty-one-day old platy fish (0.032 g and 1.17 ±0.02 cm) were randomly assigned to four treatments in triplicates and kept in a 40 l glass tank (10 fish/tank) for six weeks. They were fed with standard powdered feed twice a day to near satiety. Survival of fish was assessed daily and total length and body weight of fish were measured every two weeks. At the end of the experiment, growth performances were assessed by using % Specific Growth Rate (SGR) and Average Daily Gain (ADG). At the end of the experiment, survival rate was not affected by the treatments and significantly highest body weight (0.31±0.01 g), total length (2.7±0.04 cm), % SGR (5.38±0.06) and ADG (20.43±0.61) were recorded at 150 mg/l hardness level followed by 50 mg/l hardness level. The correlation between the total hardness of water and growth performance of platy fish were examined (R^2 = 0.889) and it clearly showed that 150 mg/l hardness level is more favorable for the growth of platy fish. Moreover, calcium uptake of platy fish reared under different hardness level was evaluated and it has increased with respect to the calcium concentration in the environment**.** It clearly indicated that environmental calcium level highly influenced the whole-body calcium uptake of platy fish in different hardness levels (R^2 = 0.9772). Furthermore, results of this study revealed that calcium hardness level up to 250 mg/l did not alter their survival, but significantly affect the growth. The present study revealed that calcium hardness level of 150 mg/l is the optimum calcium hardness level among the tested hardness levels for platy fish juveniles.

Keywords: Hardness of water, Growth performance, Platy fish, Survival

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Comparison in Hair Coat Characteristics and Physiological Parameters of Jersey Cows in Up Country Wet Zone and Dry Zone Modified Climate.

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ABSTRACT

This study is aimed to investigate the variation in hair coat characteristics and physiological parameters of pure Jersey cows in up country wet zone and low country dry zone environment modified farm in Sri Lanka. For this study, 30 milking cows (high and low yielders, non-pregnant) from each farm were selected to obtain the data. Dry and wet bulb temperatures of both farms were taken at morning (9.00a.m.-12.00p.m.), noontime (12.00p.m.-1.00 p.m.) and evening (1.00p.m.-3.00p.m.) of the day to calculate the relative humidity (RH), dew point temperature and temperature humidity index (THI). Climograph was drawn to determine the related thermal zones for the animals of both farms. Hair coat thicknesses (mm), average hair length (mm), number of hairs per unit area (number of hair per squire cm), hair angle to the skin surface (inclination angle in degrees), skin fold thickness (mm) were measured to obtained hair coat characteristics data. As physiological parameters, respiratory rates, heart rate, pulse rate, (per min.) and rectal temperature (C^0) were measured. Data underwent the analysis of Levene's test for equal variances and the means were compared by using paired t-test by considering, level of significance as 5% using MINITAB and SPSS. Correlations of regression between each physiological parameter with hair inclination angles were analyzed. Relative humidity and temperature humidity index (THI) in Dayagama farm was ranged between (87%-95%) and (69.4-70.5) respectively; while it was (87%-93%) and (77.8- 90.5), respectively in Ridiyagama farm. According to the THI interpretations, the milking cows of Dayagama farm were more comfortable than the Ridiyagama farm according to the critical level of THI (72). According to the drawn Climograph Dayagama milking cows were in thermal comfort zones while Ridiyagama cows were in high-temperature zone. The mean values of hair coat thickness (2.85±0.76vs 5.65± 1.67), hair inclination angle (14.45±4.49 vs 23.63±8.08) and skin fold thickness (11.14±2.26vs9.73±2.06) Ridiyagama and Dayagama farms, respectively) were significantly different from each other. Average hair length (13.0 ± 2.83 vs 14.73± 4.1) and hair density (1396±597.23 vs 1445.7±651.20) were not significantly different. Except for mean values of rectal temperature (38.48±0.40 vs38.27±0.4), heart rate (70.43±6.78vs64.66±6.84), pulse rate (66.40±6.77 vs60.66±6.84) and respiratory rate (54.40±9.07vs41.12±6.25) were significantly higher in cows of Ridiyagama farm. The farm level comparison between high yielders and low yielders for each hair coat character and physiological parameter did not show any significant difference. The climatic condition of Dayagama farm was considerably comfortable for the milking cows than the modified climatic condition in Ridiyagama farm. Hair coat parameters of cows showed a considerable variation based on its living climate. Yield between two farms cannot be compared due to differences in parity, management, etc. However, cows in both farms are able to maintain homeothermy by adapting to the region.

Keywords: Bioclimatology, Climograph, Haircoat characteristics, Jersey.

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Comparison of Electrical Conductivity Method of Identifying the Subclinical Mastitis with Somatic Cell Count and California Mastitis Test

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Abstract

Subclinical Mastitis (SCM) is a major problem in Sri Lankan dairy industry. California Mastitis Test (CMT) and Somatic Cell Count (SCC) are major diagnostic tools used in subclinical mastitis. The objective of study was to determine the effectiveness of the electrical conductivity (EC) method on the diagnosis of subclinical mastitis in dairy cows comparing with somatic cell count (SCC) and California mastitis test (CMT). EC method is simple and easy to be used in the field itself, than SCC and CMT method, in large scale production, using EC meter without having any complicated laboratory process. A total of 259 milk samples were collected from quarters of 59 cows as 59 bulk samples and 205 teat samples at 5 different farms. CMT, SCC and EC were recorded from each sample and analyzed based on categories according to the results of CMT; SCM negative CMT (N) and SCM positive CMT (P). CMT (positive) samples were again divided in to 4 groups based on the severity of subclinical mastitis; CMT(+), CMT(++), CMT(+++) and CMT(++++). In teat milk, 50.73% CMT(N) and 49.27% CMT(P).In bulk milk 40.68% CMT(N) and 59.32% CMT(P). In CMT(P) teat samples, 28.71%, 12.87%, 14.85% and 43.56% are CMT(+), CMT(++), CMT(+++) and CMT(++++) respectively. In CMT(P) bulk samples, 34.29%, 2.86%, 8.57% and 54.29% are CMT(+), CMT(++), CMT(+++) and CMT(++++) respectively. There is a positive correlation between EC and CMT ((R^2 = 0.444) and EC and SCC (R^2 = 0.271) in teat milk ($P<0.05$). Also there is a positive correlation between EC and CMT ((R^2 =0.413) and EC and SCC (R^2 =0.409) in bulk milk ($P<0.05$). The mean of EC of teat milk shows a significant difference between groups ($P<0.05$) and values were 4.74±0.07, 5.14±0.15, 5.60± 0.28, 5.92±0.24 and 6.75±0.16 in CMT(N), CMT(+), CMT(++), CMT(+++) and CMT(++++) respectively. Mean of SCC for teat milk were $1.78*10^5$ ±$3.71*10^4$, $3.46*10^5$±$5.38*10^4$, $7.84*10^5$±$2.19*10^5$, $9.66*10^5$±$2.46*10^5$ and $3.67*10^6$±3.7610^5 in CMT(N), CMT(+), CMT(++), CMT(+++) and CMT(++++) respectively. The mean of EC of bulk milk shows a significant difference between groups ($P<0.05$) and values are 5.15±0.13, 5.61±.074, 5.63±0.14, 5.93±0.27 and 6.30±0.16 in CMT(N), CMT(+), CMT(++), CMT(+++) and CMT(++++) respectively. Mean of SCC for bulk milk are $1.49*10^5$±$3.82*10^4$, $6.65*10^5$±$1.76*10^5$, $4.30*10^5$±$1.74*10^5$, $9.27*10^5$±$1.66*10^5$ and $3.06*10^6$±$3.91*10^5$ in CMT (N), CMT(+), CMT(++), CMT(+++) and CMT(++++) respectively. It has been concluded that EC showed similarity with the CMT and the SCC in the detection of subclinical mastitis and EC is an effective method in detection of subclinical mastitis.

Keywords: Subclinical mastitis, Electrical conductivity, California mastitis test, Somatic cell count

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Defecation Behavior and Fecal Consistency of Friesian Dairy Cows Affected by Feeding Time Associated with Milking

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Abstract

Ration composition, time of feeding and health status of dairy animals directly affect their fecal consistency (FC) and defecation behavior (DB). The objective of the study was to evaluate the effect of time of feeding [before milking (BM) vs. after milking (AM)] on the FC and DB of Friesian dairy cows fed the same ration (DM= 28.9%, CF=25.29%, CP=15.66%, N=2.5 %) on the FC and DB of Friesian dairy cows. Experimental design was a complete randomized design with ten replicates. Treatments were feeding before milking (T1) and feeding after milking (T2). Data were collected from 10 milking cows from each treatment (n=20) for 4 months. Behavior at defecation was recorded continuously for 45 seconds. In relation to feeding (FE), DB was observed continuously for 2 hrs. either before or after milking by following scan sampling method. Behavioral bouts observed were Feeding (FE), fecal discharge (FD), urination (UR), arching (AR), straining (ST) and raising tail (RT). Boot test was performed to assess the FC and scores were fixed at; 1- Diarrhea condition, 2- High watery condition, 3- Custard-like and structures recognized, 4- More thick custard like 5- Stiff feces. Significant difference ($P<0.05$) was observed in FE and FD. However, UR and AR behaviors were not significantly different ($P>0.05$). Frequency (%) FE was comparatively higher (4.0±0) BM over AM (1.2±0) in T1. It was (2.8±0) AM in T2. Simultaneously, FD was significantly ($p<0.05$) higher BM (0.70±0) in T1 compared to T2 (0.40±0). No significant difference ($P>0.05$) was observed for UR and AR (cooperate behaviors) between T1 and T2. However, UR was higher before milking compared to after milking in both treatments. Positive correlations were recorded between FC and straining time ($r^2 = 0.667$) and also between FC and FD ($r^2 =0.819$). Though time of feeding had not affected on milk yield, it showed a significant ($p<0.05$) influence on FD and FC. Score 2 fecal score was recorded in T2 indicating high watery feces associated with increased stress whereas score 3 was recorded by T1 treated milking cows showing normal feces. It is concluded that feeding should be practiced before milking to ensure the welfare of dairy cows.

Keywords: Defecation behavior, Fecal consistency, Feeding time

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Development of an Enzyme-Linked Immunosorbent Assay to Study the Prevalence of Toxoplasmosis in Cattle in Sri Lanka

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Abstract

Toxoplasma gondii infection is a zoonotic protozoan infection that affects warm-blooded animals, including cattle. In cattle, *T.gondii* can cause abortions, birth defects, and stillbirths resulting in significant economic and reproductive losses. Consumption of infected meat and milk facilitates the zoonotic transmission. The objectives of the study were to: (1) modify an existing ELISA system to measure the prevalence of Toxoplasmosis among cattle (2) utilize the above test for serological diagnosis of Toxoplasmosis in cattle (3) compare the occurrence of Toxoplasmosis among cattle from different locations in Sri Lanka and also in imported cattle. 75 serum samples from 7 areas (Ambalantota, n=10; Embilipitiya, n=10; Anuradhapura, n=13; Padawiya, n=12; Polonnaruwa, n=10; Thanamalwila, n=10 and Vauniya, n=10) in Sri Lanka and 75 serum samples from imported cattle were collected for the study. An existing indirect ELISA system described previously for goats was modified to analyze serum samples. The antibody titres of 150 samples ranged from 0.102 to 1.246. The antibody titre of Ambalantota (0.335) was higher ($p<0.05$) compared with the antibody titre of Vauniya (0.617). The difference of antibody titres between local (0.486) and imported cattle (0.408) was nearly significant ($p=0.081$). The antibody titre of imported cattle was higher ($p<0.05$) compared with the antibody titre of cattle from Vauniya. The occurrence of toxoplasmosis in some selected locations was higher ($p<0.05$) compared with other tested locations. The highest occurrence of toxoplasmosis was reported from Polonnaruwa (80%; 8/10), whereas the lowest were from Ambalantota (20%; 2/10) and Thanamalwila (20%; 2/10). In conclusion, an existing ELISA system was modified to detect Toxoplasma antibodies in cattle. Antibody titres of Toxoplasma varied significantly at some specific locations in the country. The occurrence of toxoplasmosis infection was significantly different among some specific locations and imported cattle.

Keywords: Antibody, ELISA, Occurrence, Toxoplasmosis

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Effectiveness of an Acoustic Repelling Device on Toque Monkeys (*Macaca Sinica*) Under Sri Lankan Field Conditions

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Abstract

Human monkey conflict is a critical problem in Sri Lanka. Damage caused by non-human primates to the properties, cultivations of humans and loss of their habitats, space, feed and lives of monkeys are major concerns. This study was conducted to evaluate the applicability and suitability of an acoustic monkey repelling device on repelling Sri Lankan toque monkeys under field conditions as a way to mitigate human monkey conflict. Study was carried out in 5 selected sites within the premises of University of Peradeniya for a period of 2 months. First 3 weeks were spent on preliminary observations to gain fundamental knowledge and behavior time budget of the monkeys. Collection of data was done during 4 phases at each site. During phase 1 data were collected before setting up the repellent and study number of animals present in the site were recorded. Data collection in other 3 phases was carried out after setting up the device and 3 frequency ranges (10, 18 and 25 kHz) with 115dB power were tested at each location in a Randomized complete block (RCBD) study design. During these 3 phases number of toque monkeys present on the location with repellent was recorded. One-hour observations per day were carried out for 3 days at each phase (total of 12 days). Monkeys were observed directly or using binoculars and data were recorded in written format in data sheets. The caustic repellant devise (JWP-315M, Conway Exports Private Limited, Delhi, India) was tested at for its manufacturer specified monkey repelling frequency range and covered 6000 ft^2 area. Oscilloscope and 'Lab View' software were used to test the emitting frequency ranges. Device sound pressure of 115 dB was tested using a digital sound level meter with RS232. Data were analyzed by using Minitab statistical package using Kruskal-Wallis Test. Although there was significant trend, the tested acoustic monkey repelling device is not efficient ($P = 0.058$) in reducing the number or repelling toque monkeys from a target site. Habituation to the sound waves and reduction of disable power of the sound waves over a distance could be reasons for this outcome.

Keywords: Acoustic, Behaviour, Repellent, Toque monkey

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Richness and Roost Preference of Insectivorous Bats in Tea Agro-Ecosystems in Sri Lanka

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Abstract

Insectivorous bats play a significant role in suppressing aerial insect pests in agro-ecosystems all over the world. However, occurrence of bats depends on the availability of insect prey and availability of day roosting spaces in or close proximity to agricultural lands. Tea (*Camellia sinensis*) is the major export crop grown in Sri Lanka, and contributes 0.8% of GDP in 2015. Accordingly, a study was designed to determine which of these bats occur and roost in tea plantations themselves, and the types of structures they depend on. Six tea plantations were selected to represent tea growing agro-ecological zones of WL1, WM2, WU2, WU3, IU2 and IU3 in Sri Lanka. The study was conducted during September 2016 to December 2017. Capturing of bats were done using mist nets, a harp trap, and a hand net. Eight species of insectivorous bats were recorded, representing five families include *Rhinolophus rouxii*, *Rhinolophus beddomei*, *Hipposideros speoris*, *Hipposideros lankadiva*, *Megaderma spasma*, *Pipistrellus ceylonicus*, *Pipistrellus coromandra* and *Miniopterus fuliginosus*. Three species (*R. beddomei*, *H. lankadiva* and *M. spasma*) were only recorded from roosting structures and did not capture inside tea plantations during night. *Rhinolophus rouxii* was the most common bat which recorded from all sampling sites. Total of 22 day roosting structures were recorded and majority were geomorphic 13 (59%). Out of the roosting structures in this category, caves were the most commonly occupied roosts by bats (69%). Vegetative roosting structures were the next more occupied roost category and anthropogenic roosts were the least occupied category. There are 46 species of insects identified as pests in tea plantations in Sri Lanka which represent six orders (Lepidoptera, Coleoptera, Isoptera, Heteroptera, Diptera, and Hemiptera). Estimated crop loss due to insect pest is given as 8% in general. Those insects are commonly eaten by the bats which, are recorded from tea plantations. Although protecting bat roosting structures is crucial for their conservation, it is challenging in view of existing tea management practices. Therefore, natural roosts should be maintained, protect and essential to introduce artificial bat boxes and houses. Protecting of bat roosts can help to suppress insect pests and increase tea production.

Keywords: Agro-ecosystems, Bat conservation, Chiroptera, Day roosts, Pest control

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Metal Impurities in Commercial TSP Fertilizers in Sri Lanka as Analyzed by ICP-OES Method

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Abstract

Triple Super Phosphate **(**TSP) is one of the fertilizers applied to overcome the phosphorus deficiencies in agricultural soils. Application of TSP fertilizer may be one of the major inputs of metal impurities contaminants to agricultural soils in Sri Lanka. This might result in imbalance structure of trace metals in soils leading to toxicity problem, where these toxic trace metals can enter to the human body easily through the food chain. The present study was focused on determining the metal impurities in commonly used TSP fertilizers in Sri Lanka. Two TSP samples obtained from two Fertilizer Companies (A and B) were selected for the study. Six replicates of each company fertilizers were digested using the method of the Association of Official Agricultural Chemists. The concentration of eleven trace metals (Cr, Mn, Cu, Cd, Pb, Zn, Fe, Ni, Co, Mo and As) in each TSP fertilizers were determined by ICP-OES as an analytical technique. ICP-OES analysis revealed a group of non-lethal metal species, present as impurities. The highest average concentrations were, 4229.30 mg of Fe, 469.16 mg of Mn , 195.34 mg of Zn, 8.73 mg of Ni , 7.78 mg of Cu, 2.36 mg of Co and 1.39 mg of Mo per kg^{-1} of fertilizer. Considerable amount of toxic heavy metals such as Pb, Cr, As and Cd were detected with average concentrations of 53.93 mg of Pb, 25.56 mg of Cr, 3.19 mg of As, 1.05 mg of Cd per kg^{-1} of fertilizer, respectively. Trace metal concentrations of two fertilizer companies were compared using two sample t –test ($\alpha = 0.05$). Metal concentrations of Mn, Cu and Zn were significantly higher in company A fertilizer samples than those of the company B. Concentrations of Cr, Cd, Pb, Fe, Co and Mo were significantly lower in company A fertilizer samples than those of the company B. However, there was no significant differences in concentrations of Ni and As content in fertilizer samples of company A and company B. Present study explores that concentration of trace metals in TSP fertilizers were highly varied related to the TSP fertilizer companies. At present, no regulatory limits are available for the maximum amount of trace metals present in TSP fertilizer in Sri Lankan conditions. Protocol or an act to regulate the standard limits of metal impurities present in TSP fertilizers is highly recommended.

Keywords: Arsenic, ICP-OES, Metal impurities, Triple supper phosphate

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Isolation and Identification of Oil Degrading Fungi from the Rhizosphere Soil of *Crotalaria retusa* Grown in Soil Contaminated with Used Lubricating Oil

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Abstract

Contamination of soil with used lubricating oil (ULO) is one of the major environmental issues worldwide that has not been fully attended. Unsafe disposal of ULO create negative impact on life on earth due to its major chemical constituents, hazardous polycyclic aromatic hydrocarbons (PAHs) and toxic heavy metals. Bioremediation, that uses microorganisms is one of the most promising technologies with increasing demand for the remediation of ULO contaminated soil and water because pollutants can be degraded efficiently at low cost in an ecofriendly way. The aim of the present study was to isolate and characterize ULO degrading fungi from ULO contaminated soil. Ten morphologically distinct fungi were isolated from the rhizosphere of *Crotalaria retus* grown in ULO contaminated soil. Briefly, rhizosphere soil was serially diluted and grown on mineral salt agar (MSA) medium supplemented with 10,000 mg kg^{-1} of ULO per plate. The ULO was provided as the sole source of carbon and energy. Isolates with ULO degradation potential were identified by formation of clear zone surrounding fungal growth. The two most efficient ULO degrading isolates, RUH 6 and 7 were identified as *Fusarium solani* and *Aspergillus nidulans* respectively, using colony characters and sequencing of internal transcribed spacer region (ITS) spanning the ITS1, 5.8s and ITS2 regions in the ribosomal RNA operon. The efficiency of ULO degradation by two isolates were further analyzed by using a gravimetric method in MS broth medium supplemented with 1g of ULO. *Fusarium soani* RUH 6 and *Aspergillus nidulans* RUH 7 were capable of degrading 73.5% and 76.4% of ULO, respectively. This study signifies the potential of using *Fusarium solani* RUH 6 and *Aspergillus nidulans* RUH 7 isolates for efficient remediation of ULO contaminated soil and highlight future directions for *in vivo* application.

Keywords: *Aspergillus*, Bioremediation, *Fusarium*, PAHs, ULO

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Acknowledgement: Financial assistance received from the National Science Foundation (NSF) Sri Lanka (Grant No. 16-144) is gracefully acknowledged.

Density of *Eospalax baileyi* Pallas and Effects of Compound Poison Bait with D-type Kreotoxin Poisoning *Eospalax baileyi* Pallas

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Abstract

In order to examine the density of population of *Eospalax baileyi* Pallas and improve the effects of D-type kreotoxin on *E. baileyi* Pallas, the population density of *E. baileyi* Pallas was investigated from 2013 to 2014, and different kinds of compound poison baits effects on *E. baileyi* Pallas were tested in 2014. The block-open method was used to survey the population density with three repeat grids. Rapeseed oil and peanut oil was used as attractant to make compound poison, and then determine the compound poison bait effects on *E. baileyi* Pallas. The density was 39.7 individuals/hm^2 in 2013 and 42.14 individuals/hm^2 in 2014, respectively. The results showed that the average feeding rate of rapeseed oil was 72.2%,which was significantly higher than that of peanut oil with 60% (P<0.01*)*. The average killing rate of poison bait without attractant was 77.6%, which was significantly lower than the rate of poison bait with attractant (89.7%, P<0.01). The average density of *E. baileyi* Pallas in Hongyuan county was 40.92 individuals/hm^2 which indicated that the pest was highly harmful to the grassland. The effect of D-type kreotoxin poisoning *E. baileyi Pa*llas could be significantly improved with the attractant.

Keywords: Hongyuan county, *Myospalax baileyi* Pallas, D-type kreotoxin, Attractant

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Screening of Microsatellite Markers for Early Detection of *Corynespora* Leaf Fall Disease Resistance in Rubber (*Hevea brasiliensis*) Clones

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Abstract

C*orynespora* leaf fall (CLF) caused by *Corynespora cassiicola*, is a serious disease affecting natural rubber industry. Withdrawing or downgrading of the position of number of clones in the clone recommendation leads to narrowing down of the *Hevea* breeding pool. Current study was carried out with the objectives of developing a microsatellite marker/s to screen new set of genotypes for CLF resistance in early stages of the evaluation process to strengthen the *Hevea* breeding pool with CLF resistance and high yielding clones. The clones RRIC 100 and PB 86 (CLF resistant), RRISL 201 and RRISL 208 (moderately susceptible) and RRIC 100, RRIC 103 (susceptible) were selected. Six clones, which have already been characterized, were taken as controls. Initially, thirty SSR primers (HB-1 to 4, HB 6 to 12, HB 14 to 22, HB 24 to 30, hmac 4 and hmct 5, and hmct1) were used for screening the polymorphism among parents. Four SSR Primers (HB 1, HB 11, HB 29, hmct 5) were selected according to polymorphism on RRIC 100 and RRIC 103. Thirty SSR primers were used in PCR amplification and used to build up the genetic distance matrix using power maker (V 3.0) computer program and tree diagram was drawn using *Tree view* computer program. Cluster analyses revealed grouping of four distinct clusters. All six control clones were grouped into two main clusters. According to the dendrogram derived, among three main clusters, cluster A consisted RRIC 52, cluster B contained RRIC 103, and cluster C comprised PB 86, RRISL 201, RRIC 100 and RRISL 208. The clone RRIC 103, a highly CLF disease susceptible product developed by RRIC 52 × PB 86 also deviated from resistant clones and showed moderate susceptibility. According to Genetic distance matrix, RRISL 208 and RRIC 52 had high distance value (0.1310) while the lowest value was observed between RRIC 100 and RRISL 208 (0.0250). Between RRIC 100 and RRIC 103, the genetic distance was 0.074 because they shared same parentage. According to the study, selected SSR primers showed potential to screen disease resistant *Hevea* clones against *Corynespora* leaf fall disease.

Keywords: Corynespora leaf fall disease, *Hevea brasiliensis*, Molecular markers, Resistance, SSR

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Study on Stay-Green Properties of Ancient Wheat Species and Modern Bread Wheat

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Abstract

Triticum aestivum (modern bread wheat/MBW) is a result of a number of random hybridisation events between progenitors of different ploidy levels. Genetic diversity has had an enormous impact on wheat breeding since Green Revolution in the 1960s. However, at present, the genetic diversity of MBW is narrowed due to selective breeding. One source of increased genetic diversity could be the ancient wheat species, which provide novel resources of genes to improve properties of MBW. A genotype with the ability to retain green leaf area for longer than an ordinary genotype is called a "stay-green" phenotype. They are a potential source of assimilating more carbon during the post-anthesis grain filling period hence increased grain yield. A field experiment was conducted to study stay-green properties of ten genotypes of three hulled wheat species (einkorn, emmer and spelt) and MBW in 2011-2012 at Sutton Bonington Campus, University of Nottingham, UK.A randomised complete block design was used in the experiment with four replicates. Flag leaf greenness was measured as visual greenness score, green area duration (GAD) and chlorophyll content (SPAD value). Visual greenness score was plotted against thermal time (base temperature at anthesis 0 ^{o}C) using a four parameter logistic model. Above ground biomass (AGB) and grain yield were recorded at harvest. Delayed onset of flag leaf senescence, slow senescence rate and prolonged leaf greenness were observed in spelt genotype and were positively associated with AGB production. AGB was highest in spelt followed by emmer, bread wheat and einkorn at maturity ($P<0.001$). However, bread wheat produced the greatest grain yield due to its superior harvest index. Bread wheat recorded the highest SPAD value pre-anthesis followed by spelt, emmer and einkorn ($P<0.001$) while SPAD values of spelt genotypes during the post-anthesis period was higher than all other genotypes. GAD was significantly different between genotypes ($P<0.001$) where spelt cv. Oberkulmer had the highest GAD followed by spelt cv. Tauro. Hence, it can be concluded that spelt, an ancient wheat species, could be used as a source to obtain genetic materials to increase stay-green traits of MBW.

Keywords: Ancient wheat, Anthesis, Flag leaf greenness, Stay-green

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Evaluation of the Major Failure Modes of the Nonstructural Finger Jointed Timber Species Under Tensile Test

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Abstract

A study was undertaken to evaluate the tensile strength performance and major failure modes of the finger-jointed timber species used in nonstructural productions. Finger jointing is a process for recovering valuable natural resources. Finger joint technique is used to eliminate wood defects which weaken the strength of sawn wood plank and unused short pieces can even be used for obtaining defect free longer lengths of timber. A finger profile of 13 mm finger length, 4 mm pitch and 1 mm tip width were used in the study. The sections were joined by using PVA adhesive.BS 373: 1957 and BS EN 15497:2014 Standards were used for tests. The test for tensile properties were performed using Universal Testing Machine (UTM 100 PC) with loading plate moving speed of 01mm/min and load vs. displacement variation was obtained. Maximum load could be identified to calculate ultimate tensile strength. Seven timber species commonly used for furniture manufacturing industries in Sri Lanka, including softwood Pine (*Pinus caribaea*) and hardwood Grandis (*Eucalyptus grandis*), Jack (*Artocarpus heterophyllies*), Kumbuk (*Terminalia arjuna*), Mahogany (*Swietenia macrophylla*), Satin (*Chloroxylon swietenia*) and Teak (*Tectona grandis*) were used in this study. The major failure mode of the nonstructural finger jointed 7 timber species subjected to a tensile test was mainly due to glue line failure (47.14%), followed by wood grain failure (24.28 %) and fiber failure (15.71%). The least failure mode was weak finger joint (12.85 %). The highest mean finger joint strength was obtained from Grandis (50.23 N/mm^2) timber species and least mean finger joint strength was recorded in Kumbuk (16.88 N/mm^2) timber species.

Key words*:* Finger joint, Glue line failure, Tensile strength

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Effect of Mulching on "Green Coronet" Cabbage (*Brassica oleracea*) Cultivation in Welimada Area

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Abstract

Mulches give many benefits in vegetable production, although their use has not been studied under home garden conditions. Cabbage is one of the major vegetables cultivate in large extent mainly in the up-country area as a year-round crop. Mulches are principally use for strawberry cultivation in Nuwaraeliya district, but still not field of vegetable cultivation. Hence, present study was carried out to identify the most effective and suitable mulch material on cabbage cultivation. This study was done at farmer fields located in Welimada area. Healthy 25-27 days old cabbage seedlings were used as planting materials. The seedlings were transplanted on flat beds. Following applications were made as the treatments giving attention on mulching: (i) no mulch (control) (T1), (ii) white polytene (T2), (iii) silver polytene (T3), and (iv) weed slash (organic) (T4). Treatments were assigned in a complete randomized block design (RCBD) with five replicates. Measurements were commenced at the second week after transplanting given the fact that the plants were fully established and continued weekly until the time of harvesting. The data collection included measurements related to following growth parameters: leaf area (cm^2), head girth, (cm), fresh mass (g), dry mass of whole cabbage (g), length of roots (cm), no of roots, no of leaves and weed infestation. Data were subjected to analysis of variance (ANOVA) using Minitab 16 statistical package. Mean comparison was undertaken following the turkey test, at p= 0.05. Results showed that mulch type significantly ($P<0.05$) affected on growth and yield of cabbage and weed infestation. There was significant difference ($P<0.05$) between yield of cabbage heads from plots mulched with white mulch and silver mulch. Silver mulches showed burning effect for cabbage production. White mulch was most suitable mulch material according to leaf area, head girth, fresh mass, dry mass, length of roots, number of roots, number of leaves and weed infestation parameter for cabbage production. The control treatment showed that lowest yield of cabbage production. White mulch could be recommended to increase the Green coronet cabbage production in up country.

Keywords: Mulch, *Brassica oleracea*, Green coronet, Weed infestation, Growth and yield

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Effects of Compost on Growth and Yield Performance of Finger Millet (*Eleusine coracana* L.) Under Low Input Conditions in Southern Dry Zone Region of Sri Lanka

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Abstract

Finger Millet (*Eleusine coracana* (L.)Gaertn) is a native plant to Africa belongs to family Poaceae and is a popular crop in tropics because of its high nutritional value. Finger millet is a continuously grown crop in low country dry zone in Sri Lanka, without using fertilizers. The regular depletion of nutrition status of land and the degradation of soil properties due to continuous cultivation in same lands without using fertilizers have resulted decreasing the productivity of finger millet. This study was carried out to determine the effects of compost on finger millet yield under the rain-fed condition during the 2015/16 and 2016/17 Maha seasons at the Grain Legume and Oil crops Research and Development Center of the Department of Agriculture. Different compost levels (0MT/ha, 1MT/ha, 2MT/ha, 3MT/ha, 4MT/ha, 5MT/ha and 6MT/ha) were tested as treatments in a Randomized Complete Block Design with 4 replicates and a treatment of without application of compost was used as the control. The levels of N, P and K levels of the compost which used in the experiment were 0.93, 0.34 and 0.6, respectively. The plot size was 9 m^2. Particular amounts of compost applied to the soil as treatments before seed sowing in both seasons. Along with compost used inorganic fertilizers (only half of basal application mixture with Urea, Triple super phosphate and Muriate of Potash 25kg each) for finger millet recommended by Department of Agriculture, Sri Lanka (DOA). All other practices were done as recommended by DOA. At the end of the 1st season of the research unable to see considerable enhancement of growth performances as a result of application of compost but at the end of 2nd season results showed clear enhancement of the number of productive tillers, plant height and grain yield of finger millet. The results revealed that the effect of compost application on yield cannot be seen in one season, continuous application of compost leads to obtain higher yield in finger millet cultivation.

Keywords: Compost application, Growth performances, Finger millet, Rain-fed condition

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Shank Skeleton Morphology, Egg Quality Characteristics and D-loop Phylogeny of Asil Chicken Breeds (Pora Kukula) in Sri Lanka

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Abstract

Chickens are considered as one of the most valuable domesticated animals originated from red jungle fowl and have extreme geo-morphological variation. The study reported here in was focused on comparing the shank skeleton characteristics, external egg quality traits and mtDNA D-loop phylogeny among indigenous Sri Lankan chicken breeds namely Asil chicken (Pora Kukula), village chicken (Gam Kukula) and Ceylon jungle fowl (*Gallus lafayettii*).The study was carried out in all agro-ecological zones in nine geographical provinces in Sri Lanka. 189 of male and female birds were used to collect the data. Seven external quality traits such as Egg weight (EW) in g, Egg Length (L) in cm, Egg width (W) in cm, Egg shape Index (ESI) in %, Egg volume (EV) in cm^3, Shell Weight (SW) in g, Shell Ratio (SR) in % and six internal quality traits such as Yolk Weight (YW) in g, Albumin Weight (AW) in g, Yolk ratio (YR) in % and Albumin ratio (AR) in percentage were examined. Mean, Standard Deviation, Analysis of Variance (ANOVA), Least Significant Differences (LSD) and co-efficient of variance were computed by using SAS (Version 9.3.01) Software. Results revealed that egg weight, yolk weight, shell weight and shape index were differed significantly ($P<0.05$) among the chicken breeds. It was also noted that Asil chicken had more pointed eggs. However, shank length and skeleton morphology were not significantly different ($P>0.05$) among breeds. Phylogenic analysis revealed that two main haplo groups of indigenous chicken in Sri Lanka. D loop sequence were deposited in Gene Bank and obtained accession numbers of fighter chicken male, fighter chicken female, village chicken male and jungle fowl male were KX954631, KX954630, KX 954632, KX 954643, KX954633, KX954635, KX 954637, KX 954629, KX954636, KX954628, KX954627 and KX 954629, respectively. This study concluded that Sri Lankan village chicken and Asil chicken breed were grouped into different clades and the possible reason might be their different genetic makeup. The selected egg quality traits of Sri Lankan Asil chicken breed and their genetic variation correlated.

Keywords: Asil bird, D-loop sequence, Egg quality traits, Shank morphology

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Distribution and Diversity of Economically Important Bivalves and Shrimps in Rekawa Lagoon in Sri Lanka

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Abstract

The present study was undertaken to study distribution, diversity and correlation of bivalves and shrimps community in relation to environmental factors in Rekawa lagoon. Samples were randomly obtained from 19 selected sites in Rekawa lagoon and were separated by wet sieving method and identified up to family and genus level. In addition to that available mangrove species, sea grasses, soil texture, plankton diversity were recorded to investigate their correlation with bivalves and shrimp. Two types of benthic bivalves belonging to family Corbiculidae were identified up to the family level and they were most abundant in Parappuwa. *Macrobrachium* sp, and *Atya* sp. were recorded as shrimp species in the lagoon. In addition to that *Pseudocalanus elongates*, *Calanus* sp. and *Naviculas*p., were identified as planktons. Mean pH, ambient temperature, salinity, dissolved oxygen, water temperature and depth values of the lagoon were respectively 7.5, 36.3 C^0, 21ppt, 11.2mg/L, 31.6 C^0, and 70.3cm. Sand, clay and muddy soil textures were identified. Sea grasses *Halophilaovalis, Hallophila, H. minor* and *Ruppia maritime* and mangroves such as *Aegicera scorniculatum, Avicennia marina, Avicennia officinalis, Bruguiera sexangula, Ceriopstagal, Excoecaria agallocha, Heritiera littoralis, Lumnitzera racemosa, Nypa fruticans, Rhizophora mucronata* and *Sonneratia caseolaris* were among the identified species. In this study a significant correlation ($p<0.05$) between sea grass *Halophila, H.ovalis*and both *Macrobrachium* Sp. and *Atya* Sp.,water temperature and distribution pattern of *Atya* species, salinity level and *Macrobrachium* Sp., Dissolved Oxygen and *Macrobrachium* Sp., and water depth and *Atya* Sp. were observed. Shrimp fishery was observed as the main economic activity while *Penaeus indicus*, *Penaeus monodon*, *Penaeus semisalcatus*, *Macrobrachium rosenbergii* were recorded in the lagoon and off shore catch. Though diversity of bivalves is very low in Rekawa lagoon, diversity and availability of shrimp is very high due to government shrimp stocking programs and favorable water quality parameters.

Keywords: Bivalves, Mangroves, Planktons, Rekawa lagoon, Shrimp

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Effects of Elevated Atmospheric Temperature and CO_2 Concentration on Rice Spikelet Fertility in Australian Rice Production Systems

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Abstract

More than 50% of the world's population consumes rice as the staple food while Australia produces 1.2 million tons of rice annually and feeding about 40 million people daily. Future climate change predicts increase temperature and reduced rainfall patterns which could severely affect rice production. As rice yield heavily relies on spikelet fertility factor, this study predicted the spikelet fertility factor with response to different rice varieties in different future climatic scenarios (related to increasing temperature, elevated atmospheric CO_2 concentration and rainfall) using APSIM–Oryza model at two different sites, Griffith in New South Wales and Kununurra in Western Australia. Varieties used at Griffith were Quest, Amaroo, and Langi representing early, mid and late maturity types, respectively. Only single variety (IR72) was used for Kununurra region. Five incremental changes of temperature were 0 (base), +1, +2, +3, +4^oC with amalgamation of five rainfall changes (+10, 0, -10, -20, and -30%) used in the simulation to characterize the variety of projected climatic changes predicted for Australia over the following 60 years. The corresponding CO_2 concentrations connected with the above temperature levels were 380, 435, 535, 640 and 750 ppm. In all varieties of Griffith (Amaroo, Langi, and Quest),spikelet fertility factor showed an increasing trend up to 1-2 ^oC temperature increase which could be due to CO_2 fertilization effect. Further increase in temperature caused a steady decline in spikelet fertility factor, with short-season variety 'Quest' affected least. In contrast to the Griffith Riverina region, in Kununurra, spikelet fertility factor changed negatively with the temperature increase, decreasing from 0.55 to 0.25.These results specify that warmer temperatures are likely to increase spikelet sterility. Adaptations may comprise using shorter season varieties and changing planting dates. Therefore future rice breeding strategies should focus on developing short season varieties with higher spikelet fertility to cope up with higher temperature effects in the future.

Keywords: Climate change, CO_2 Elevation, Elevated temperature, Rice, Spikelet fertility factor

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Exploring the Perceptions of Experts on the Merits of Eco-Friendly Technologies to Reduce Chemical Fertilizer Usage in Paddy Farming in Sri Lanka

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Abstract

The use of agro-chemicals and inorganic fertilizers in Sri Lanka has a detrimental impact on environmental and safety in paddy farming. As a suggestion for above interrogations, there is an ongoing multi-stage multi-objective research study funded by the National Research Council (NRC) of Sri Lanka as an innovative concept referred to as "Eco-Friendly Technologies (EFTs)". This research explores the attitudes and perceptions of purposive sampling of 32 experts in Sri Lankan agricultural research field, universities and organizations regarding the use of EFTs. 'Slow release fertilizer', 'Organic carbon' and 'Microbes' are produced by several work packages of this project and those are incorporated into the root ball of the rice plant at the nursery stage and then healthy seedlings are established in the paddy fields by way of 'Parachute Technology'. Experts revealed their views in relation to six major criteria pertaining to EFTs with compared to broadcasting method which is considered as most popular rice establishment method and transplanting which is the best alternative method, including: (1) Acceptance; (2) Cost; (3) Environment; (4) Performance; (5) Regulation, and (6) Services. The scores provided by them on attitudinal statements on a 10-point like rt-scale were subjected to the tests on Scale Reliability and Unidimensionality and derived Aggregate Mean Scores. The results revealed that perceptions of experts on EFTs were in a "better" position in comparison to Broadcasting with respect to: Environment (-1.19), Performance (-1.17) and Regulation (-0.62) and "poor" on: Acceptance (1.60), Services (1.28) and Cost (0.99). In the context of EFTs vs. Transplanting, expert perceptions were "better" with regard to Cost (-0.79), Acceptance (-0.71) and Environment (-0.14) and "poor" on Services (0.30), Regulation (0.29) and Performance (0.23). This research concluded that acceptance, cost and services are the key factors considered by experts when replacing broadcasting method by EFT and services, regulation and performance are the key factors considered by experts when replacing transplanting method by EFT. As suggestions from this study it is important of setting up a proper institutional framework which is required to produce, promote and regulate these technologies before those EFTs are released to the society at large in order to avoid common policy failures that everybody will be seen and experienced in relation to paddy and fertilizer markets in the country as suggestions from this study.

Keywords: Eco-friendly technologies, Expert perceptions, Inorganic fertilizer, Paddy cultivation

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Social Integration Among the Undergraduates with Different Ethnic Background in the Faculty of Agriculture, University of Ruhuna

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Abstract

Effective social integration makes undergraduate life more enjoyable and productive. Social integration into a new set-up is a challenging task for an undergraduate, irrespective of the ethnicity. The objective of the present study was to compare the level of social integration of undergraduates of three ethnicities at the Faculty of Agriculture, University of Ruhuna (FAUR). Students' interaction with peers, university support services and the off-campus community and social integration index (SII) were used to determine the level of social integration. Using pre-tested structured questionnaire, information related to above three levels of interactions were collected from 63 randomly selected Sinhala, all Tamil (n=35) and Muslim (n=24) second-year undergraduates. Social integration index was developed considering the performance of the six criteria. For each criteria, deviation of the existing performance (A) from a set threshold (T) value was calculated to determine the performance of each criteria towards the social integration. Subsequently contributions of each criteria were summed [$\sum \pm(1-\frac{A}{T})$] to construct SII. Among the five closest university friends of a Sinhala student, there were no Tamil or Muslim students. The closest five friends of both Tamil and Muslim students had friends of other ethnicities. Percentages of students who engaged in extra-curricular activities were not statistically different among three ethnicities. Percentages of Tamil and Muslim students who knew 10 key officials of the Faculty were significantly higher than that of Sinhala student. Compared to Sinhala, Tamil students had visited significantly a higher number of religious, cultural and tourist attractions around the area and knew more families live around the Faculty. Though not statistically different (Chi-square $p>0.05$) among three ethnicities, more Tamil (63%) and Muslim (74%) than Sinhala students (52%) admitted that all three ethnicities have socially well integrated. The social integration index of Sinhala (-3.10) students was lower than that of Tamil (-1.2) and Muslim (-1.8) students'. Undergraduates identified language barriers, low knowledge about other cultures and attitudinal problems lower the social integration among them.The study concludes that both Tamil and Muslim students have achieved better interaction with peers, university administration and community resulting in a higher level of social integration than Sinhala students. All ethnic communities admitted the situation is not perfect and thus interventions are needed for further improvements.

Keywords: Ethnic, Social integration, Undergraduates

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Study on Morphological Traits of Wild Rice Species Collected from Different Agro-ecological Regions in Sri Lanka

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Abstract

Wild relatives of genus *Oryza* play an important role in rice breeding program worldwide. To achieve sustainable crop improvement, wild relatives of rice are important as a genetic resource. The objective of this study was to explore the promising traits in species identification to distinguish wild rice species in Sri Lanka in terms of morphology. In this study, the rootstocks of five wild rice species (*O. nivara, O. rufipogon, O. eichingeri, O. rhizomatis and O. granulata*) available in Sri Lanka were collected from their natural populations representing different ecological conditions. To search for variation patterns and distinguish features which can be utilized for identification among species, plants were established in a common garden. Morphological diversity was measured by 11 quantitative traits following rice descriptor of IRRI. A considerable variation of morphological characteristics was found among the five wild rice species for the most of the traits measured. The results of the analysis of variance indicated that the total evaluated quantitative traits showed more variations among the species ($P<0.05$). The significantly highest plant height (184.75 cm) with seedling height (100.00 cm), culm length (152.25 cm) and culm diameter (7.3 mm) were showed in *O. rufipogon*. In contrast, *O. nivara* had significantly the highest grain width (2.625 mm) and 100-grain weight (1.955 g) compared to the other species. However, *O. eichingeri* and *O. rhizomatis* had *a* lower value of 100-grain weight than the other species. Whereas both *O. rufipogon* and *O. nivara* exhibited, significantly the highest flag leaf length and grain length than the other species. Moreover, flag leaf width of the *O. nivara* and *O. rufipogon* were significantly lower than the other species. In contrast, *O. granulata* had significantly larger flag leaf width (2.05 cm) but significantly the lowest plant height, culm diameter, panicle length, and flag leaf length compared to the other species. *O. eichingeri* exhibited significantly the shortest culm length (42.0 cm). Therefore, the morphological diversity information of wild rice species could be useful in rice breeding program and species identification in field level.

Keywords: Diversity, Field identification, Quantitative traits, Wild rice

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Spatial Variability of Available Soil P and K and its Impact on the Site Specific Nutrient Management of Paddy

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Abstract

Adopting blanket fertilizer recommendations can cause imbalances in supply of plant nutrients. The present study was conducted in Kurunegala, Anuradapura and Polonnaruwa districts to investigate the variability of initial soil Phosphorus (P), Potassium (K) levels and yield response for P and K to explore the suitability of site specific nutrient management (SSNM). Surface soil (0-15 cm depth) samples were collected in 28 paddy fields before commencement of the growing seasons: *yala* 2017 and *maha* 2018 and analysed for available P and K. Treatment plots of each site comprised of an ample treatment applied with 50% higher rates than that of N, P_2O_5 and K_2O recommended by Department of Agriculture (DOA) and omission treatments of P and K. Except the nutrient omitted, other nutrients were applied in ample quantities in omission treatments. Total yield of each plot was recorded at harvesting. Initial soil P and K levels were compared with the critical levels (high, medium and low) established by DOA for a site specific application of P and K. Soil analysis showed that soils of 14% of sites were high in P (> 10 mg kg^{-1}), soils of 43% of sites were low in P (< 5 mg kg^{-1}), and soils of 43% of sites were medium in P (5 – 10 mg kg^{-1}). Initial soil K level was high (80 – 160 mg kg^{-1}) in 36% of sites, low (< 40 mg kg^{-1}) in 14% of sites and medium (40 – 80 mg kg^{-1}) in 50% of sites. The coefficient of variance (CV) of the initial P and K levels were 93% and 47%, respectively. These CVs indicated considerable spatial variability of available K and P contents of paddy growing soils. However, omission plot trails did not show a clear yield response for added P and K, revealed the short-term availability of P and K in soil masks the impact of their variability on crop growth. It was concluded that a considerable variability of P and K present in the paddy grown soils in three districts but its short-term impact on the variability of yield does not support the site-specific nutrient management.

Keywords: Paddy, Phosphorus, Potassium, Site specific nutrient management

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Evaluation of Seed Vigor of Nine Selected Traditional Rice Varieties of Sri Lanka

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Abstract

There is an increasing demand for traditional rice varieties due to their nutritional and medicinal value. Standard germination test (SGT) used for rice seed testing, does not accurately predict the field emergence (FE). Therefore, the objective of this study was to determine whether the accelerated aging (AA) seed vigor test can be used to predict FE of nine popular traditional rice varieties (Beheth Heenati, Herath Banda, Kahawanu, Madathawalu, Pachchei Perumal, Pokkali, Sudu Heenati, Sulai and Suwandel). For the SGT, four replicates, each containing 100 seeds, were germinated according to AOSA paper towel method. To calculate FE of seedlings, four replicates of 400 pre-germinated seeds each from each variety were sown in 1 m^2 plots in a paddy field at Pelwehera, Sri Lanka. To evaluate seed vigor, seeds from each variety were aged at three different temperatures (42, 43 and 44 °C) for two different time durations (72 and 96 hours) in a water-jacketed incubator. Germination of aged seeds was tested according to AOSA paper towel method. In each experiment, normal seedlings (%) were calculated after seven days. Data were analyzed using proportion analysis. Normal seedlings (%) in the SGT and FE test were >85% and >75%, respectively for all the tested varieties. In the two varieties Beheth Heenati and Sulai, the normal seedlings (%) in FE test was similar to that of SGT (P>0.05) while in other varieties, FE (%) was significantly lower than SGT (%) (P<0.05). Pachchei Perumal and Sulai showed the highest vigor (>75%) under 44 °C for 96 hours, while suwandel showed the lowest vigor (2±1%). For Beheth Heenati, Herath Banda, Madathawalu, Pokkali, Sudu Heenati and Sulai, more than one AA treatment could predict FE. To predict the FE of the tested varieties, AA conditions 43 °C for 72 hours, 44 °C for 96 hours and 42 °C for 72 can be recommended for Herath Banda, Pachchei Perumal and the other tested varieties except Kahawanu, respectively. To select the best AA parameters to predict FE of Kahawanu, more combinations of temperature and time of exposure need to be tested.

Keywords: Accelerated aging, Seed germination, Seed vigor, Traditional rice

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Effect of Bacterial Inoculation on Growth and Yield of Onion (*Allium cepa* L.) in Kilinochchi Under Greenhouse Conditions

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Abstract

The search for microorganisms to improve soil fertility and crop production has continued to attract attention to offset the negative impacts of fertilizers in the environment in an eco-friendly way. The objectives of this study were to screen beneficial bacterial strains from onion (*Allium cepa* L.) rhizosphere from Thiruvaiyaru area in Kilinochchi district for the ability to fix nitrogen, solubilize phosphorus and/or to produce indole-3-acetic acid; and to select efficient strains in terms of onion productivity. Seven bacterial strains were screened for their N fixing and P-solubilization potential. The selected isolates together with previously screened three bacterial isolates were tested in a pot experiment under greenhouse conditions to evaluate their efficiency in improving growth, and yield of onion. The treatments were arranged in a completely randomized design with four replicates. The treatments were T_1 (Non-fertilized), T_2 (Rec NPK), T_3 (Azo1), T_4 (Azo3), T_5 (Azo4), T_6 (Azo5), T_7 (Azo6), T_8 (TSA1), T_9 (TSA2), T_{10} (Azoj2), T_{11} (Azoj4), T_{12} (OD) and T_{13} (Cattle manure: CM). T_2 (Rec NPK) was treated with recommended dose of CM (10t/ha) and NPK fertilizers; Urea (195kg/ha), Triple supper phosphate (100kg/ha) and Muriate of potash (75kg/ha). For the treatments T_3 to T_{12} were treated with respective inoculum, CM (20t/ha) and Muriate of potash (75kg/ha). T_{13} was treated with CM (20t/ha) alone. All the inoculated plants showed significantly comparable height and number of leaves /plant with T_2 (Rec NPK) throughout the growing season except T_9 (TSA2). The highest and the lowest dry matter were produced in T_7 (Azo6) and T_9 (TSA2) respectively. The onion yield was increased by 24%, 25%, 20%, 20% and 31% in T_3 (Azo1), T_4 (Azo3), T_6 (Azo5), T_7 (Azo6) and T_{11} (Azoj4), respectively compared to T_2 (Rec NPK). There was a positive correlation observed between yield and uptake of nutrients, nitrogen and phosphorus. Therefore, the bacterial strains Azo1, Azo3, Azo5, Azo6 and Azoj4 have the potential to improve the growth and yield of onion compared to other tested strains. It is also suggested that further studies under the field conditions are needed to confirm the efficiency of screened strains.

Keywords: Bacterial strains, Growth promotion, Onion, Yield

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Effects of Organic and Inorganic Amendments on Salinity Levels of Municipal Solid Waste Composts in Sri Lanka

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Abstract

Composting is considered as an appropriate and affordable strategy to mitigate the problems related to Municipal Solid Waste (MSW) management in developing countries. One important concern related with MSW compost is extreme salinity levels revealed by high Electrical Conductivity (EC). As a remediation measure, it was suggested to amend organic and inorganic substances together with MSW compost. We hypothesize that using organic and inorganic compounds at the production stage may reduce the salinity of MSW composts. Accordingly, the objective of this study was to examine the effects of two selected amendments (Gliricidia leaves as organic and gypsum as inorganic amendments) addition at the production stage to reduce the extreme salinity levels of MSW composts in Sri Lanka. Slightly decomposed (one month) MSW were collected from Weligama (S1) and Malimbada (S2) compost production units in Southern Sri Lanka. They were amended with Gliricidia and gypsum at the rates of 5, 10, 20, 30, and 40% (dry basis) separately. Samples were allowed to decompose under aerobic conditions, while frequent mixing and moistening. At the complete decomposition (8 weeks after amendments), pH and EC of the samples were tested in triplicates using 1:2.5 and 1:5 solid: water ratio (EuTech PC 700 electrode), respectively. The data were statistically analyzed using ANOVA. Results revealed that, pH of all the treatments of S2 MSW compost became significantly low compared with the control except for those with 5% Gliricidia. This might be due to acidifying effects of organic acids produced during the decomposition. However, the pH values of all the treated samples from both sites were in the standard pH range (5.5-8.0) which is favorable for composting. The control samples were from strongly to very strongly saline with EC values of 19.24±0.16 mS/cm (S1) and 10.41±0.61 mS/cm (S2). With the application of amendments, EC values of both sites were reduced. The 5% Gliricidia amended samples showed slightly-moderately saline levels. This might be due to salts leaching and excess Na^+ removal from exchange complex sites of compost. The EC values increased from 5% up to 30% Gliricidia rate which might be due to increasing organic matter content. Amending of Gliricidia at the lowest used rate (5%) with highly saline MSW compost is more effective in reducing salinity and in the terms of cost effectiveness. Further experiments are required to explore the effects on soil productivity and quality under field conditions.

Keywords: Compost, Electrical conductivity, Municipal solid waste, pH, Salinity

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Acknowledgement: This work was financially supported by National Research Council (Grant No: NRC 14-19)

In-vitro Shoot Regeneration of *Pterocarpus marsupium* (Gammalu)

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Abstract

Pterocarpus marsupium (Fabaceae) is a multipurpose leguminous tree, commonly called as Gammalu. The wood is useful in chest pain, body pain, indigestion and the paste of seed and wood is useful in diabetic. Its propagation through seeds; germination rate is very poor due to impermeable seed coat and stem cuttings is also difficult. Due to these factors, the species is at the verge of extinction and will extinct soon if suitable steps are not taken for its conservation. The present study was carried out to find suitable concentration of Cytokinins (BAP) for shoot multiplication of *Pterocarpus marsupium*. Mature seeds were germinated on MS (Murashige and Skoog) medium. The cotyledonary nodes as explants were cultured on MS medium supplemented with BAP and Auxins (NAA), in combinations (0-Control, 0.5, 1.0, 1.5, 2.0mg/L BAP with 0.1mg/L NAA) for shoot induction. Five replicates per each treatment was carried out. Data were analyzed according to a CRD model using SAS (Version 9.1.3) software. Maximum shoot multiplication (3) per explant was achieved on MS medium fortified with BAP (1.5mg/L) and NAA (0.1mg/L) within minimum (16) days. MS medium without plant growth regulators was showed poor shoot regeneration (0.4) within higher number (27) of days. It can be concluded that, 1.5 BAP + 0.1 NAA can be use in large-scale production of plants and may useful to further *in vitro* experiments on *P. marsupium*.

Keywords: Cotyledonary node, *In vitro* shoot multification, *Pterocarpus marsupium*

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A Case Study on Effect of Herbicides and their Mixtures on Weed Control and Yield of Rice (Var. At 362) at Akuressa and Athuraliya Divisional Secretariat Divisions in Matara District of Sri Lanka

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Abstract

The present study was carried out to examine the effect of weed control and yield performances of At 362 paddy variety in response to the type of herbicide and their combinations in Akuressa and Athuraliya Divisional secretariat divisions within the agro-ecological zones WL2a and WL2b respectively in Matara district. This research comprised of a survey using a pretested questionnaire and field data collection with the participation of 100 farmers in 2016/2017 Maha season. Random sampling technique was employed to select farmers. Primary data was collected through several focused group discussions with agricultural instructors. Yield parameters of paddy and weed data were recorded at 60 and 95 days after field establishment. t-test and Kruskal-Wallis one way ANOVA were used to analyze the results. According to the data obtained from this survey farmer fields were first divided into 4 categories based on the method of post emergent weed control (single chemical(T_1), mixed chemicals(T_2), no chemical (T_3)and both chemical with mechanical(T_4)) and subsequently 2 categories based on field establishment method (broadcasting and transplanting). Highest percentage of farmers used mixed chemicals (44%) for weed management. T_1, T_3 and T_4 methods were used by 20%, 16% and 20%, farmers respectively. Fields which used T_4 method gave significantly higher total yield when compared only with T_1 treatment. Broadcasted fields with T_1, T_2 and T_3 weed management methods gave significantly higher yield than transplanted fields under similar methods of weed management. Degree of weed control was more than 95% in all weed control methods. These results revealed that if adequate labor is available no chemical method can be used and it gives considerably higher yield similar to chemical applied fields for weed control. It also enhances the environmental health and food quality. This survey also revealed that, it is meaningless to apply mixed chemicals for weed control, when compare the yield and the degree of weed control with single chemical application. Chemical application and mechanical weeding (T_4) with transplanting is the most suitable practice for better performance of paddy and weed control. Therefore, strong awareness campaign on herbicide application is essential to educate farmer. However further research in several seasons need to be performed to understand the exact effects of various weed management methods on rice yield and weed density of the paddy field.

Keywords: Broadcasting, Herbicides, Paddy, Transplanting, Yield

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Candidate Gene Identification for *Rvi5* Apple Scab Resistance in Apple Cultivar 'Murray'

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Abstract

Apple scab, caused by fungal pathogen *Venturia inaequalis,* is a severe disease of cultivated apple (*Malus × domestica* Borkh.). It is the most studied plant–pathogen interaction of woody plant species using genetic, genomic, proteomic and bioinformatics approaches in both species. Until now 17 monogenic resistances against the disease have been identified in different *Malus* species and some of them are currently used in scab resistance breeding programs. However, the evolution of virulent pathogen strains that has ability to overcome the monogenic resistance raised the need to define new strategies to obtain a durable resistance in apple breeding. Gene pyramiding becomes a successful method to obtain plants with durable resistance. Recently, the *Rvi5* (Vm) apple scab resistance from the cultivar 'Murray' was fine mapped and the region carrying the resistance was restricted into a region of 1cM flanked by two SSR markers (FMACH_Vm4 and FMACH_Vm2). In this study, three bacterial artificial chromosome (BAC) clones spanning the resistance locus were identified, completely sequenced and assembled, which allowed identifying the putative *Rvi5* locus in a region of 154kb in size. The open reading frame prediction and functional annotation of the identified region revealed the presence of one putative gene homologous to TMV resistance protein N-like [Malus x domestica] characterized by a Toll and mammalian interleukin-1 receptor protein nucleotide-binding site leucine-rich (TNL) repeat structure.

Keywords: Apple scab, Candidate gene, *Rvi5*, TNL genes*, Venturia inaequalis*

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Evaluation of the Factors Influencing on the Accuracy of UAV Measured Height

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Abstract

Remote sensing-based analysis of geographical information systems (GIS) has reached a new level with the use of unmanned aerial vehicles (UAV) especially in the field of precision agriculture by analysing orthomosaics, digital elevation models and vegetation indices generated by UAV imageries. With the use of UAV, it is possible to collect remote sensing data without cloud coverage, at a lower cost and higher accuracy than satellite and aerial imageries. Accuracy of UAV height data is critical for remote sensing-based GIS analysis used in precision agriculture. Therefore, the goal of this study was to evaluate the factors influencing for the accuracy of UAV height data. A UAV was tested for height measurements at three different height levels along a height pole. Total of 240 height measurements were recorded with four types of flying conditions, namely (a) continuous flying with Global Positioning System (GPS) on, (b) continuous flying with GPS off, (c) landing reset flying with GPS on, and (d) landing reset flying with GPS off at three height levels 2m, 5m, and 10 with 20 recurrences each. Average, standard deviation (SD), root mean square (RMSE), and mean absolute error of heights measurements were calculated for each condition. Further, two-way analysis of variance (ANOVA) test was carried out on mean absolute errors of height measurements to determine the effect of factors GPS and landing reset on height accuracy. Averages of height measurements showed that flying with landing reset resulted in height measurements closer to the actual height values and SD of measured heights showed that low precision in height measurements during continuous flying. RMSE confirmed that flying with landing reset with GPS off achieved the highest accuracy. There was no significant difference of mean absolute errors found between flying with GPS on and off. The significant contributing factor was the flying with landing reset. The results concluded that UAV height measurements are more accurate when the UAV is flying with landing reset, while flying with GPS on or off did not make any significant effect on UAV height measurements. On the other hand, flying with GPS on facilitates geotagging which is mandatory for GIS analysis and helpful for easy operation of UAV. Therefore, it is recommended to operate a UAV with landing reset while having GPS on in a situation where a UAV is deploying to gather remotely sensed data at different altitudes.

Keywords: Height accuracy, Precision agriculture, Remote sensing, UAV

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Comparison of Vibration Power Applied into a Modified Bark Peeling Tools for the Reduction Force Required for Cinnamon Processing (*Cinnamomum zeylanicum*)

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Abstract

At present, cinnamon (*Cinnamomum zeylanicum*) is the main processed spice export from Sri Lanka. However, the industry is facing a challenge to meet its skilled labour demand due to its special nature of processing steps. Bark peeling is the removing step of cinnamon bark after scraping and rubbing steps in which the force required is second only to the rubbing step. The existing peeling tools are inefficient and that demands strenuous arm power. Therefore, this study assess the possibility of reducing required force for cinnamon peeling by using vibration assisted peeling tools when they were applied different levels of vibration. Three eccentric rotating mass motors (RF-555, R260 and MABUCHI RF-M50WA) that were different in their power ratings as 2.4W, 1.125W and 0.5W were used in the experiment. A traditional peeling knife was modified to fix to the above motors as one motor at a time to evaluate the operating performances. A voltage regulator was used to obtain the best operating power for each motor type. Cinnamon sticks (diameter 3.5cm and length 10cm) were peeled out for 5mm width strip at all peeling operations. The peeling force was recorded as 10 data points per second in real-time by using Sundoo SH-500 force gauge. The stroke speed of the peeling knife was -40cm/min. As a control, similarly sticks were tested without vibration effects. Data were analysed through one way ANOVA to select the better force reduction ratings. Results revealed that there was a significant reduction of force when using all three motor types compared to the control. Moreover, the force reductions were directly proportional to the applied vibration strengths in the studied range. The motor with the highest power ratings 2.4W (RF555- ERM), offered the highest force reduction (78.6%) to the control while the other two motor types with lower power ratings (1.125W) and (0.5W) recorded respective lower performance (69.8 % and 36.1%), force reduction to the control. Therefore, it is recommended to test the performance with further elevated operation power (greater than 2.4W) for further force reductions. All three motor types recorded their best operating performance when the applied voltage level reached to 70% to 80% to their maximum allowable voltage ratings. The results have shown that the potential possibility of using eccentric rotating mass vibration motors in vibration assisted tools for the reduction of force required for bark peeling forces of cinnamon sticks.

Keywords: Bark peeling force, Cinnamon (*Cinnamomum zeylanicum*), Eccentric rotating mass vibration motors (ERM), Frequency-acceleration, Mechanical vibration assisted tools

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Study on the Inhibitory Effect of Arctigenin and Nobiletin on Human Lung Adenocarcinoma Cell-Specific Metabolic Inhibition

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Abstract

Cancer cell is generated by gene mutation when normal cells divide into cells. In Japan, many people die of lung cancer. An antitumor agent is one of the methods for treating malignant tumors. However, although antitumor agents have an inhibitory effect on many malignant tumors, it shows a high side effect on normal cells. So far, scientists of the University of the Ryukyus have found a component that exhibits strong anti-cancer effects on lung adenocarcinoma cells A549. Arctigenin (ARC)and Nobiletin (NOB) showed strong anti-cancer effects on A549 cell. This study investigated the effects of lung adenocarcinoma cells by adding ARC and NOB contained in food using A549 cells. The MTS assay measures the viable cell ratio and cell activity by utilizing the reduction reaction of intracellular mitochondria. The PI assay measures cell viability by staining reagent with nuclei in cells killed by methanol fixation. A 549 was cultured in 96 well plates at a concentration of 2.0×10^4 cells / well. After 24 hours, ARC and NOB were added to 96 wells at concentrations of 0, 2.5, 5, 10, 20 and 40 μM respectively. After 48 hours, the MTS reagent was added and the absorbance was measured at 490 nm. After MTS measurement and washing with PBS, the sample was added with 100% methanol and incubated at room temperature for 10 minutes. Then, it was washed with PBS, added with 10 nM PI reagent, and incubated at room temperature for 1 hour. Then, the absorbance was measured at 536/600 nm. The synergistic effect can be determined by comparing the actually measured value with the value multiplied by the sample given alone. In MTS assay, a synergistic effect was observed when the ARC was 10 and 20 μM , and the NOB was 5 and 10 μM. In PI assay, more than 80% of the cell nuclei was stained with PI reagent. Then, when only ARC and NOB were added, the PI reagent stained more than 85% of the cells. Experimental results showed inhibitory effect in MTS assay, but high cell viability in PI assay. This result suggests that it is possible to suppress the degradation of MTS reagent performed by mitochondria in cancer cells. Future study will be conducted to evaluate the effect of simultaneous treatment of ARC and NOB in cancer cells using metabolome analysis.

Keywords: Antitumor agents, Arctigenin, Cancer cell, Nobiletin

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Prediction of Feed Compositions in Ecofeed by Near Infrared Spectroscopy (NIRS)

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Abstract

Ecofeed is an animal feed made from food, beverage and agricultural by-products and that is expected to reduce feed processing cost, increase feed self-sufficiency in Japan and urge effective utilization of unused resources. However, ecofeed has some disadvantages like unstable chemical composition because of high water contents in the feed, variable supply of the materials, and so on. Therefore, rapid determination of the nutritive compositions is needed for managing the feed and materials quality, and calculating feed formulation. Therefore, near infrared spectroscopy (NIRS) is focused as a rapid analysis method of nutritive value of feedstuffs. In this study, NIRS calibration models for predicting feed nutritive compositions, crude protein (CP), ether extract (EE), crude ash (CA), crude fiber (CF) and nitrogen free extract (NFE) in ecofeed and the materials collected in Okinawa were developed. In this study, 121 samples (ecofeed and the materials) were collected from industrial waste collector in Okinawa. Then, 100 samples were used for creating calibration models (calibration sets) and 21 samples (validation sets) were for evaluate the models. Collected samples were oven dried at 65˚Cfor 48h and powdered finely. The feed nutritive compositions in CP, EE, CA CF and NFE were analyzed by using general methods. NIRS scanning was done by NIRS instrument (InfraXact, Foss AB, Hillerød) and the absorbance was measured in 2nm increments from 570 nm to 1848 nm. After scanning, the spectrum data were differentiated twice and the calibration models developed by multiple linear regression (MLR) and partial least squares regression (PLSR). Moreover, created models were evaluated by coefficients of determination of calibration (R2C), standard deviation of calibration (SEC), coefficients of determination of validation(R2V), standard deviation of prediction (SEP) and ratio of performance to deviation (RPD; Standard deviation (SD) of analyzed value in validation sets.SEP-1). All PLSR calibration models were better than MLR models. R2C, SEC, R2V, SEP and RPD values of PLSR model were 0.94, 2.52, 0.98, 2.02 and 6.83 for CP, 0.93, 2.29, 0.98, 1.14 and 7.82 for EE, 0.59, 2.61, 0.32, 1.63 and 0.98 for CA, 0.81, 1.82, 0.75, 1.79 and 1.90for CF, and 0.95, 4.07, 0.94, 3.98 and 4.16 for NFE, respectively. Williams (2001) suggested that calibration model with RPD > 3.1 is suitable for screening and model with RPD > 6.5 is suitable for process control. Considering the above result, CP, EE and NFE calibration models could be developed with high accuracy by PLSR.

Keywords: Animal feed, Food and beverage byproducts, Near infrared spectroscopy,

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Factors Affecting Growth, Yield and Quality of Turmeric (*Curcuma* spp.)

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Abstract

Turmeric (*Curcuma* spp.) is an important plant having both medicinal and food values. It is widely cultivated throughout the tropical and subtropical regions of the world, especially in Asian countries, mainly in China, India, Pakistan, Bangladesh and Myanmar. The processed rhizome of this plant is commonly used in Asian cuisine as an important constituent of curry powder, dye for food and textile, and as cosmetics additive. The plant contains bioactive molecules that possess pharmacological properties like antioxidant, anti-inflammatory, antimicrobial, anti-fertility, anti-venom, hypocholestraemic, hypolipidemic, antirheumatic, antiviral, antifibrotic, antivenomous, antihepatotoxic, antidiabetic, antinociceptive, anticancerous, and gastroprotective properties, antialzheimer anticoagulant, digestive stimulant. The plant has also shown to possess anti HIV activity to combat AIDS. Turmeric demand is increasing in the world day by day due to the medicinal values. Therefore, it is necessary to improve yield and quality of turmeric. It is very general that growth, yield and quality of a plant species differ with the climatic and edaphic factors, cultivation methods, fertilizer managements, etc. In this paper, planting time, relative light intensity, soil types, chemical fertilizer, farmyard manure and green manure have been evaluated on growth, yield and quality of turmeric in Okinawa, Japan. Turmeric planted in different months withered in December and January. Shoot and yield of turmeric plants were significantly higher in the April planting followed by the March and February plantings than in the late planting. Turmeric shoot biomass, yield and curcumin content increased markedly at 59–73% relative light intensity (RLI) as compared with the control plant. However, the degree of RLI required for better turmeric cultivation may vary with the place, year and irradiance level. Turmeric cultivated in dark-red soil (pH 5.2) provided significantly highest yield with higher curcumin content than in gray soil (pH 7.4) and red soil (pH 4.4). Seed rhizome of 30-40g or mother seed-rhizome (shoot base) provided higher shoot and yield of turmeric. Seed rhizomes planted at 8-12 cm depth in a triangular patter on two-row ridge with 75-100 cm width provided higher yield. The combined application of fertilizer N and K (NK) or N, P and K (NPK) provided 4-6 times greater shoot and 8-9 times higher yield. The fertilizer K resulted highest curcumin content in rhizome but did not provide considerable yield. Cow manure, goat manure and chicken manure improved soil physical and chemical properties and provided nutrients which resulted in significantly higher yield. Crotalaria (*Crotalaria spectabilis* L.) and hairy vetch (*Vicia villosa* R.) green manures maintained soil pH at 6.5-7.0 and reduced the soil bulk density by 19%. Shoots remained green 30 days longer, and shoot and yield increased by 173-197 and 28-86%, respectively, when turmeric was grown with the green manures. Hairy vetch alone provided 46% higher yield, while crotalaria provided similar yield, compared to the fertilizer treatment. Curcumin concentration (%) in the rhizomes was lower by 4-54%. The above results indicate that yield and quality of turmeric differ significantly with the climatic and edaphic factors, and management practices.

Keywords: Anti-inflammatory, Antioxidant, Curcumin

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Food and Nutrition

Evaluation of Microbial Quality of Unfermented Coconut Sap Collected Under Two Different Systems by Molecular Approaches

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Abstract

Unfermented coconut sap is one of the natural drinks, being traditionally tapped from unopened inflorescence of coconut palm. Unfermented coconut sap undergoes rapid fermentation after contacting with the microorganisms present in the atmosphere; hence the quality of the sap is deteriorated. In the present study, two different sap collection systems were evaluated, namely traditional clay pot system and a poly-bag collection method treated with *Vateria copallifera*. The microbial quality of collected sap was evaluated through molecular methods. DNA was extracted by the modified Cetyl Trimethyl Ammonium Bromide (CTAB) method from the microbial colonies isolated from the collected coconut sap by the two collection systems. ITS1 forward (5' TCCG TAG GTGAACCTGCGG 3') and ITS4 (5' TCCTCCGCTTATTGATATGC 3') reverse primers were used for yeast species and 27 forward (5'-AGAGTTTGATCCTGGCTCAG-3') and 1492 reverse (5'-CGGTTACC TTGTTACGACTT-3') primers were used for the bacterial species for Polymerase Chain Reaction **(**PCR) amplification. PCR products were analyzed using 1.5 % agarose gel and amplified specific bands were purified with wizard PCR clean-up system. Purified PCR products were subjected to DNA sequencing. Three types (A, B, C) of distinct microbial colonies were isolated from the sap samples collected by two methods. DNA homology data analysis by BLAST concluded that, A, B and C isolates are *Serratia marcescens, Achromobacter xylosoxidans* and *Saccharomyces cerevisiae* respectively. *Saccharomyces cerevisiae* is the responsive microorganism for fermentation. *Serratia marcescens* and *Achromobacter xylosoxidans* are environmental abounded opportunistic pathogen and it restricts the direct consumption of unfermented coconut sap. Therefore, hygienic practices need to be applied to increase the quality of coconut sap.

Keywords: Microbial quality, Unfermented coconut sap, Universal primer

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Effect of Star Fruit (*Averrhoa carambola*) Peel Extract on Oxidative Stability of Sesame (*Sesamum indicum*) Oil during Storage

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Abstract

Edible plant oils such as sesame (*Sesamum indicum*) oil with a high content of polyunsaturated fatty acids are susceptible to oxidation during storage. Recently, following evidences on the adverse effects of synthetic antioxidants on human health, there is a growing interest in the use of plant sources as natural antioxidants in edible oils. This study investigated the effect of addition of star fruit (*Averrhoa carambola*) peel extract on oxidative stability of sesame oil during storage. Antioxidants present in the peel were extracted by using acetone and antioxidant properties of the extract were determined. Oil samples were purchased directly from a mill ensuring that the oil is not adulterated and does not have any added antioxidants. Initial value of Free Fatty acid content (FFA) and Peroxide Value (PV) were 2.64±0.35 g oleic acid /100g and 0.26±0.06 meq /kg of sample, respectively. Samples were prepared separately in glass bottles by adding 1000 ppm of star fruit peel extract (treatment) and 200 ppm of butylated hydroxytoluene (BHT) (positive control) and without adding antioxidant (negative control). Glass bottles were filled up to the top with the respective oils, hermetically sealed and kept at ambient conditions in a dry and cold place. Two sets of experiments, one set exposed to sunlight and other without exposing to sunlight, were carried out. The level of oxidation was determined by FFA, PV, *p*-anisidine value (AV), TOTOX value, conjugated diene (CD) and conjugated triene (CT) values after one month and two months of storage. All parameters of non-exposed samples were significantly lower ($p<0.05$) than the respective exposed samples. TOTOX values of negative control, positive control and treatment in non-exposed samples after two months of storage were significantly lower (4.11±0.03, 3.55±0.1 and 2.31±0.18, respectively) than exposed samples (10.99±0.35, 7.84±0.08 and 5.79±0.15, respectively). PV, AV and CD and CT values of treatment samples in exposed and non-exposed samples (1.55±0.11 and 0.46±0.13 meq/kg, 2.69±0.06 and 1.4±0.08, 0.96±0.008 and 0.90±0.001, 0.89±0.01 and 0.85±0.01, respectively) were significantly lower ($p<0.05$) than the values of corresponding positive controls (2.39±0.07 and 0.57±0.02 meq/kg, 2.98±0.13 and 2.42±0.06, 0.97±0.001 and 0.94±0.05, 0.91±0.00 and 0.90±0.00, respectively). In conclusion, star fruit peel extract at 1000 ppm significantly reduced the oxidation of sesame oil exposed to light up to two months of storage and its effectiveness was higher than BHT. Thus, star fruit peel extract could be used as a green alternative to synthetic antioxidants in edible oils.

Keywords: Acetonic extract, Antioxidants, Peroxide value, Photo oxidation

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Selection of Best Drying Method of *Neolitsea cassia* Leaves as to Preserve a Local Mucilaginous Material for Food Industry

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Abstract

Continuous supply of raw materials is a most common problem in food industry. *Neolitsea cassia* ,is the most common materials used to extraction of mucilage in Sri Lanka. Mucilaginous materials extracted from *Neolitsea cassia* was used as textural improvers, thickeners, stabilizers etc. Due to lack of continuous supply of the raw material, introducing this mucilage into food industry is a challenging issue in food industry. Hence, preservation of materials is an important task. Drying is the most common and easy way to preserve raw materials. Therein, *Neolitsea cassia* leaves were subjected to four different drying methods namely solar drying, mechanical drying, dehumidified air drying and shade drying. Mucilaginous material was extracted manually in 1% citric acid solution and filtered. Viscosity and the dry matter content were measured for each drying method. They were compared with mucilaginous material extracted fresh leaves. Results revealed that, there was a significant difference ($P \leq 0.05$) in both viscosity and the dry matter content between dehumidified air drying over other drying methods. Dehumidified drying exhibited the highest viscosity and yield which was 3.75±0.05cP and 2.85±0.03g/kg% respectively. Dehumidified drying able to retain its original properties which was nearly same as that of fresh leaves, 97.40% and 99.65%, respectively. Shelf life study showed a significant retention of viscosity over six months for dehumidified drying. Hence dehumidified air drying was identified as the best drying method to preserve *Neolitsea cassia*leaves as a local mucilaginous material for food industry.

Keyword– Drying techniques, Dehumidified drying, *Neolitsea cassia* leaves, Mucilaginous material, Food security

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Traditional/Indigenous Knowledge on Processing of Different Traditional Flour Varieties and Their Food Applications in Rural Communities in Sri Lanka

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Abstract

Traditional flour based foods have been consumed by Sri Lankans for centuries especially due to their uniqueness and nutritive value. The traditional and indigenous knowledge on usage of natural resources for processing of traditional food is passed from generation to generation. However, this knowledge and skills appear to be rapidly disappearing due to contemporary life styles of the people. Therefore, the present study focused on documentation of traditional food resources used to formulate different traditional flour varieties and their food applications. A number of visits were paid to randomly selected villages within selected divisional secretariat divisions based on agro ecological zones in Southern, Central and Sabaragamuwa provinces in Sri Lanka. Information was collected from purposively selected women, elders over 65 years and farmers through face to face interviews. According to discussions, 20 edible plant species were identified as natural resources for the preparation of flours. Grains (Rice, *Oriza sativa;* Finger millet, *Eleusine coracana*; Foxtail millet, *Setaria italic*; Millet, *Panicum miliaceum*; Sorghum, *Sorghum bicolor*; Kodo millet, *Paspalum scrobiculatum*; Maize, *Zea mays*), tubers (Elephant yam, *Amorphophallus campanulatus*,), roots (Cassava, *Manihot esculentus*, Hulankeeriya, *Maranta arundinacea*), fruits (Beraliya, *Shorea megistophylla*), seeds (Madu, *Cycas circinalis*; Hal, *Vateria copallifera*; Green gram, *Vigna radiata*; Black gram, *Vigna mungo*; Horse gram, *Dolichosbiflorus*; Nelum, *Nelumbo nucifera*), palm cabbage (Sago palm, *Caryota urenes*; Tala, *Corypha umbraculifera*) and flowers (Mi, *Madhuca longifolia*) were identified as commonly used natural resources for formulation of different flour types in the experimental area. The mostly used traditional method of formulation of flour is wet, semi-wet grinding by using mortar and pestle at the households. Millet grains are milled by a non-motorized grain mill by hand, called "kurahan gala". The traditional way of producing flour from palm cabbage is by pounding the pieces of inner core of the tree using a mortar and pestle. Widely consumed flour based traditional breakfast meals include 'roti', 'pittu', 'thalapa', hoppers and string hoppers made out of rice, finger millet, millet, foxtail millet, 'kithul' and 'hal', and gruels made from finger millet, millet, foxtail millet, and 'kithul' flour. A large range of sweetmeats including 'Kewum', 'Athirasa', 'Aluwa', 'Welithalapa', 'Kokis' and 'Naran kewum' are prepared by using all types of flours. The findings of the present study will benefit the future society in preserving and sustaining the traditional food preparation and creating awareness among Sri Lankans.

Keywords: Indigenous knowledge, Natural resources, Traditional flour, Traditional foods

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Progressive Freeze Concentration of Coconut Water Using a Simple Cylindrical Apparatus

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Abstract

There is a growing global demand for coconut water as a beverage due to its health benefits rather than artificial drinks. Most of the concentration techniques operate on a temperature around or above room-temperature. This will lead to the deterioration of the original quality of the liquid. Freeze concentration (FC) is the most suitable method for coconut water over evaporation and membrane concentration methods since FC operates below 0^0C. Suspension Freeze Concentration (SFC) and Progressive Freeze Concentration (PFC) are the available FC methods. SFC is a complex and expensive method compared to PFC which requires a high investment cost. PFC is a novel freeze concentration method using a simple apparatus which removes water molecules from the liquid by attaching to the progressively growing single ice front. At proper operating conditions with a low crystal growth rate, the concentration efficiency is high. The objective of the present study was to develop a PFC method for the high-quality concentration of coconut water. A simple cylindrical apparatus was used for PFC which consists of a sample vessel, agitator system, and a cooling bath (Ethylene glycol/Water). Optimum operating conditions of the apparatus were found using standard sucrose solutions. The final concentration of the liquid product was directly affected by the agitator speed and sample vessel dipping speed. PFC agitator speed of 290 rpm and dipping speed of 1.3cmh^{-1} were reported as the optimum operating conditions to achieve the highest concentration for the used PFC apparatus in the present study. Using optimized agitation speed and dipping speed, coconut water was concentrated up to Brix 8.5^0 from the initial concentration of Brix 3.5^0. The total yield (based on brix) of the Progressive freeze concentrated coconut water was 0.669 ± 0.10 (67%).

Keywords: Coconut water, Freeze concentration, Progressive freeze concentration, Simple cylindrical apparatus, Suspension freeze concentration

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Aroma Volatile Production During Natural Ripening of Ambul Banana (*Musa acuminata*, AAB)

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Abstract

A study was conducted for the identification of aroma compounds in *Ambul* banana (*Musa acuminata*, AAB) and to study the development of aroma profile during natural ripening process. Mature green banana was obtained from Dankotuwa, Sri Lanka and kept to naturally ripen at 25 ^{0}C and 80% RH. Aroma profile was analyzed in 48 hours intervals using Headspace- Solid Phase Microextraction (HS-SPME) as a sampling method and gas chromatography with mass spectrophotometer for the analysis of compounds. Twenty-eight aroma compounds were detected in fully yellow stage (stage 6) of *Ambul* banana while 13 compounds were detected in unripe green stage (Stage 1). Carbonyl compounds were the mostly available type of compounds in the aroma profile of unripe fruit where 2-hexenal was major. During ripening number aroma compounds were increased as well as the number of esters. At stage 6, 19 esters, 4 carbonyl compounds, 3 alcohols and 2 phenolics were recorded. Butanoic acid, ethyl ester; 3-methylbutyl acetate; butanoic acid, 3-methylbutyl ester and butanoic acid, propyl ester were found as the most abundant esters. Hexanal and furan, 2-pentyl were detected at all stages during the ripening process. 2-Hexenal, 1-Hexanol and nonanal were detected until stage 4 whereas they become absent at stage 6. The aroma profile of banana gets rich with the development of the fruit contributing to the fruity aroma of banana.

Keywords: Banana aroma, Natural ripening, Odour active compounds, Solid phase micro extraction.

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Banana Vinegar Production and Evaluation of Antioxidant and Polyphenol Activity

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Abstract

Vinegar is one of the popular and major culinary ingredient in Sri Lanka since ancient times. The main raw material of Sri Lankan vinegar is coconut water. In Sri Lanka, the sole use of vinegar is for cooking purposes. The concept of drinking fruit vinegar that is rich in many secondary metabolites such as antioxidants, is novel to Sri Lanka. Thus, the current study was conducted to, develop a drinking fruit vinegar from the banana variety 'Ambul' that licit great post-harvest losses. In this study, we intended to test two vinegar production methods as continuous (M1) and semi- continuous (M2) fermentation at ambient temperature using a locally isolated *Acetobacter pasteurinus* strain (PP21) which was isolated from papaya (*Carica papaya*). In both M1 and M2 fermentations, the extracted banana juice was adjusted to 20° brix and fermented by adding yeast (*Saccharomyces cerevisae)* and *Acetobacter* strain PP21. In M1 method, both yeast and acetic acid bacteria were added together at the beginning of fermentation and, in M2 method, the AAB strain was added after 03 days of ethanol fermentation and were allowed to ferment for seven days. The acetic acid yield of each method was determined. At the end of the fermentation, M1 method gave an acetic acid yield of 47.8 g/L and the M2 method yielded 33.5 g/L at the fourth and seventh day of fermentation, respectively. At the stage of peak acetic acid production, the TS content of M1 and M2 were found to be 9.78 mg/mL and 3.54 mg/mL, respectively. The EC 50 value for antioxidant activity of both M1 and M2 were found to be 6.56 and 35.19 respectively, and the total phenolic content of both vinegar types were found to be 680.43 (GAE/L), 216.67 (GAE/L), respectively. Further, successful production of mother vinegar was observed in banana vinegar developed through M1 method, which may be the main reason for higher values of bioactive products in vinegar from M1 method. Thus, as a whole, 'Ambul' banana variety can be used in production of drinking vinegar. Further analysis of the product need to be done, including sensory analysis and further development, to develop the product up to the level of consumption.

Key words: *Acetobacter pasteurinus,* Fermentation, Total phenolics, Vinegar mother

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Effects of Holding Temperature and Time on Physicochemical Characteristics, Sensory Attributes and Microbial Quality of Marinated Broiler Breast Meat

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Abstract

A study was conducted to investigate the interactive effects of holding temperature and holding time on physicochemical, sensory and microbial quality of unmarinated and marinated broiler breast meat using four different techniques. A factorial (4x2x2) arrangement of treatments in a complete randomized design was used in evaluating four techniques (i.e; unmarinated control, immersion, injection and tumbling), two holding temperatures (4^{o}Cand 8^{o}C) and two holding times (4 and 8 h). A total of 128 deboned breast meat samples (weighing 30±5g each) obtained from 32-days old broiler chickens were marinated using a commercial marinade mixture and allocated into treatment combinations. Injection method resulted the highest ($P<0.05$) marinade uptake. Significant ($P<0.05$) three-way interactions were observed for cooking yield, cooking loss, external surface yellowness (b*) and internal surface lightness (L*) of breast meat. Injection (all temperature vs time combinations), immersion (4^{o}C-4h and 8^{o}C-8h) and tumbling methods (4^{o}C-4h; 4^{o}C-8h and 8^{o}C-4h) resulted the highest cooking yield ($P<0.05$). Injection and tumbling marinated meat resulted the minimum cooking loss. Minimum cooking loss was also evident in immersion marinated meat held at 4^{o}C-4h and 8^{o}C-8h. Marination methods ($P<0.05$) increased the external surface yellowness (b*) than unmarinated control. Marination reduced ($P<0.05$) the internal surface (L*) of the different marination methods and immersion method resulted the highest L* value ($P<0.05$) of meat when held at 8^{o}C for 8h. No holding temperature, holding time and marination method interactions were observed for meat pH, marinade loss, drip loss, and meat hardness. Holding at 8^{o}C for 8h after tumbling marination reported the highest score for aroma, surface colour, marinade penetration, colour penetration and overall acceptability. The total microbial counts of all the treatment combinations when tested at 2, 4 and 6 weeks period were ranged between 3.30 and 4.45 log CFU/g. Holding meat at 4^{o}C for 8h after injection marination maximally contributed to the development of the meat quality. Broiler breast meat when held at 8^{o}C for 8h after tumbling marination attracts the panelists most. All the products tested in the present study considered suitable for human consumption within 42 days when stored at -18^{o}C.

Keywords: Broiler breast meat, Immersion, Injection, Marination, Tumbling

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Analysis of Nutritional Composition of Developed Flavour Enhancer using Natural Ingredients with Umami Taste

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Abstract

The main objective of this study was to determine proximate composition of a flavour enhancer formulated using locally available natural ingredients with umami taste as a replacement for Mono Sodium Glutamate (MSG). Powdered mushrooms, tomatoes, carrots and garlic were used as ingredients. Eight different formulations were formulated with taguchi L8 design. Sensory assessment was carried out to determine the acceptability of the developed product. The study was carried out to determine nutritional profile of the final product. Physicochemical parameters such as moisture, fat, protein, fiber, free fat and mineral content were determined for the developed product according to the Standard AOAC methods. Consumption of a single vegetable in order to get the mouth feel for glutamic acid would not be a long lasting practice as far as the food patterns of Sri Lankan consumers is concerned. Therefore, using a mixture replacing MSG would be a much advanced practice considering the health issues and the addictive behaviour on MSG. Carbohydrate percentage was calculated by using following formula: Carbohydrate % = 100 - (fat% + protein% + ash% + fiber% + moisture %). Free fat content was determined according to the soxhlet extraction method described in Pearson's Chemical Analysis of Food, 9th edition. Micro Kjeldhal Method was used to determine the crude protein content of the product. The moisture and crude fiber contents were determined according to the AOAC Official Methods of 925.10 and 978.10 respectively. The gravimetric method was used as per the AOAC Official Method, 923.03 to calculate the total ash content of the product. According to the results carbohydrate, fat, protein, moisture, fiber, ash and energy were 57.8%. 13%, 0.6%, 5.3%, 15%, 20% and 245Kcal/100g, respectively. Along with an intention of replacing the consumption of MSG, the results of this study makes known that formula 767 would be a better combination to develop the said natural flavour enhancer.

Keywords: Flavour enhancer, Proximate analysis, Umami

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Development of Cost Effective Vegetable Biscuit with Locally Available Materials and Evaluation of Its Physico-Chemical, Microbiological and Sensory Properties

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Abstract

Vegetables play an important role in human nutrition, being mostly low in fat and carbohydrates, but high in vitamins, minerals and dietary fiber. Biscuit is most popular flour based baked food product in all over the world. The proposed study aimed to investigate the utilization of locally available nutritious vegetables to develop cost effective wheat flour based vegetable biscuit and to evaluate its physio-chemical, microbiological and sensory properties. Wheat flour, margarine, sugar, eggs, salt, baking powder and vegetables including carrot (*Daucus carota*), cowpea (*Vigna unguiculata*) and moringa leaves (*Moringa oleifera*) were used as ingredients for biscuit production. Accordingly, the dehydrated each of vegetable powder were incorporated together as carrot (65%), cowpea (25%) and moringa leaves (10%) to prepare mixed vegetable powder and biscuits were then prepared with mixed vegetable powder which was substituted for 0%, 5%, 10%, 15%, 20% and 25% of wheat flour. The best consumer preferred sample was selected using a semi trained panel consisted of 30 members and the selected biscuit was further examined for its nutritional and microbiological qualities. The data obtained from the experiment were analyzed using Minitab computer software (version 17.1). The results of the sensory evaluation were shown that the average scores for all the sensory attributes were higher in 10% substitution than those of biscuits substituted with different levels of mixed vegetable powder. The results of nutritional analysis showed that the moisture, total ash, crude fat, crude fiber, protein and carbohydrates content of the selected vegetable biscuit were 4.31±0.37%, 3.0±0.16%, 15.84±0.16%, 5.12±0.12%, 9.63±0.1% and 61.90±0.8%, respectively. The average vegetable biscuit diameter, thickness and spread ratio were 54 mm, 4 mm and 13.5, respectively. The results of total plate count (TPC) and yeast and mould count for the selected best biscuit product after two months of period were found to be 1.02×10^{-4} CFU/g and 0.6×10^{-4} CFU/g, respectively without addition of any artificial preservatives and it was found to be within the acceptable standard levels. Eventually, it can be concluded that the dehydrated mixed vegetable powder can be effectively used to produce biscuits in order to increase nutritional improvement of flour based biscuits.

Keywords: Carrot, Cowpea, Drumstick, Value-addition, Vegetable biscuits

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Socio-economic Interventions and Agribusiness Management

Keynote Speech

Future of Agriculture: Challenges and Sustainable Solutions

C.J.P. Siriwardana
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A growing population, rapid urbanization and increasing income of people are major determents of the global food demand. By 2050, global populations are expected to increase to 9.8 billion from 7.7 billion in 2018. The income of people globally is estimated to increase around 2 percent annually while global urban population are estimated to increase from current level of 55 percent to 68 percent by 2050. According to the forecast that has been made to estimate future demand for food, the food production needs to be increased by 70 percent by 2050 in comparison to the food production in 2007. While the demand for food will increase with the growing population, increased Income and rising population in the urban sector will lead to diversification of dietary habits replacing traditional systems and move and increase the demand for quality food by shifting towards high protein foods from starchy foods.

At the same time, the agriculture sector faces continuously occurring and rising trend of supply disruptions. In a more regular interval, incidents of unexpected climate changes, newly formed pest and diseases, lowering soil fertility, limited availability of virgin lands and exiting growers in the agriculture sector mainly due to low productivity of the agriculture and other social reasons are major supply disruptive factors that will make significant negative impact to the global food supply in the future.

Sri Lankan agriculture sector is not an exception and the sector has been undergoing through similar set of demand and supply issues. In the demand side, Sri Lanka has to produce more foods with diverse products in order to cater to rising population with higher purchasing power and living more in urban centers. In the supply side, Sri Lankan agriculture sector has been experiencing a changing weather patterns, particularly rain fall patterns, land degradation, fragmentation of land holdings and leaving of labor from the industry. In this environment, meeting the self-sufficiency and maintaining the food security will be a challenging task in the future.

Currently, Sri Lanka agriculture sector plays a multifaceted role in the economy. It includes a production of food and maintenance of sufficient stocks in order to maintain the food security which is the prime task to meet the demand uninterruptedly. In addition, agriculture sector provides raw materials to the industrial sector and to the services sector that help to maintain vibrant operations of those sectors in the economy. Further, agriculture exports, and agro based industrial products have a substantial share in Sri Lankan exports there by helping earn foreign exchange and to improve the balance of payment situation in the economy.

However, the share of the agriculture sector in the country's national output, export, labor force participation and providing its inputs into other sectors of the economy has been declining over the past. Currently 27 percent of labor force engage with agriculture sector which produces only 7 percent of gross domestic production (GDP). As a result, the productivity in the agriculture sector is 4 times lower than industrial sector productivity and 5 times lower than the service sector productivity in economy. The focus of the future agriculture is therefore largely towards

to improve the productivity in order to maintain the sustainability in the sector. With this policy strategy, agriculture sector would be able to play an important role as a supplier of labor to the other productive sectors in the economy while meeting the future food demand.

In this growing scenario, maintaining the sustainability in the agriculture sector is a challenging task which need a comprehensive policy and strategic shift to address both demand and supply side issues in the future. Developing the sector towards a Climate – Smart Agriculture (CSA) is considered as the sustainable option to address these challenges and ensure the food security in the economy. In this process, the sector needs to introduce new farm management concepts using modern technology to increase the quantity a well as quality of production. This high-tech innovation would help to move the sector towards increasingly people less faming systems. Bringing new technologies such as Gene-editing is another area to be developed to increase the productivity and to produce much wider variety of crops according to the demand of people. Further, with the consolidation of farm lands, high tech-solutions will change the entire operational process of the agriculture sector in the future. In addition, introduction of climate friendly farm management practices would help the long term sustainability of the sector. These new innovations will help to optimize process and uses of available limited resources and efficiently use of existing arable lands. In this process, the sector has to spend more on R&D and extension services for the rapid transformation of the economy.

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Sustainability of Micro, Small and Medium Enterprises (MSMEs) in Sri Lanka: Determinants of the Business Success – A Case Study in Kurunegala District

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Abstract

The Micro, Small and Medium Enterprise (MSME) sector plays a major role in Sri Lankan economy. It immensely contributes to regional development, employment generation and poverty alleviation. Hence, this sector has been identified as the backbone of the Sri Lankan economy. In Sri Lanka, despite the fact that some MSMEs have been declining or stagnant, some other have been successful and growing. The focus of this study was to identify the key determinants of business success among MSMEs in Sri Lanka which affect the long-term sustainability of them. The study surveyed 120 entrepreneurs using a questionnaire which comprised the demographic information of the respondents and a set of items to measure business success. Five-point Likert scale anchored by strongly disagree and strongly agree were applied to measure perceived business success. In addition to descriptive statistics, t-test, ANOVA and regression analysis were employed by using SPSS 16 statistical software to generalize the findings. It disclosed that, marketing, technology, access to capital, government support and infrastructure are the key determinants of business success that affect the long-term sustainability of MSMEs. The study further revealed that the inherent businesses were more successful than the businesses which were established by themselves and the educational background did not give applicable skills for running the business. These findings suggest that MSMEs should crucially focus on improving their marketing strategy, acquiring and demonstrating advanced sophisticated technology, and getting capital access to obtain sustainable business success. Other interested parties with development of MSMEs such as government agencies, business development services, and business supporting institutes should also be prepared to offer the needed assistance with relate to those aspects.

Keywords: Business success, Determinants, Enterprise, Micro, Sustainability

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Explore the Exporters' Perception Towards Branding for Ceylon Cinnamon

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Abstract

Brand is the right tool to bring the products quality is known by the final consumers, to distinguish from the competitor and to reward the quality through a higher price. The research was intended to explore the exporters' perception toward branding for Ceylon Cinnamon to win the international market by following a mix method approach. This study was mainly consisted with interviewer administered questionnaire where the respondents were 40 Ceylon Cinnamon exporters out of the sample-frame which was prepared using 3 national databases, 8 focus group meetings representing major Cinnamon growing areas. Of the sample, 15% of the companies who engaged in Cinnamon industry has 40 years of industry experience and limited number of licensed exporters who acquired the Pure Ceylon Cinnamon trade mark given by the Export Development Board (EDB). Majority, 71% were engaged in the bulk exporting in composition of Ceylon Cinnamon export basket. Cinnamon, century old business but mainly export minimally processed Cinnamon; as in bale form. Oleoresin was the top gainer followed by bark oil and fractionates even as branded or non-branded. Exporters were given strongly positive perception towards the image of the country of origin since international buyers essentially looking forward it. The effect of country of origin image over private brands and Pure Ceylon Cinnamon trade mark were identified as nonlinear relationship. Product quality, price, level of value addition, buyers' bargaining power influence on brand perception. Of the sample, 41% stated there were no special branding strategy for Cassia due to the cheap price compare to the Ceylon Cinnamon. Cassia was the direct competitor for the price concern markets. Suggestions were obtained from the in-depth interviews conduct with Cinnamon exports were summarized as qualitative data. The suggestions were; to conduct an end market survey, allocate more room for consumer packs, quality packaging, clinically proven health benefits, usage of more viral media are some of suggestions were discussed. However, as a country, as an industry still far behind to outline the Ceylon Cinnamon by using new branding competencies to suppress the global competition originate from Cassia.

Keywords: Branding, Ceylon cinnamon, Country of origin

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Remote Sensing Based Land Degradation Monitoring In Bolgoda Lake and River Network, Sri Lanka

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Abstract

The rapid utilization of remote sensing satellites and techniques has provided a reliable, effective, and near real time possibilities to characterize terrestrial ecosystem properties. Water body extraction by using remote sensing has been the most significant method in the investigation of water resources. Remote Sensing Satellite images can play a significant role in investigation, dynamic, monitoring and planning of water resources. In this paper, a study has been conducted to detect the changes in water body extent during the period of 2008 to 2017. Bolgoda lake and river network were selected as the study area to monitor and analysis the changes of the water body. Multiple methods including supervised classification (Support Vector Machine (SVM)) and vegetation index method (Normalized Difference Water Index (NDWI), Modified Normalized Difference Water Index (MNDWI), and Normalized Difference Vegetation Index (NDVI)) are analyzed in order to maintain the accuracy and cross check of the outputs. Landsat-5 Thematic Mapper (TM) imagery and Landsat-8 Operational Land Imager (OLI) have high spatial, temporal and multispectral resolution and therefore provides reliable and accurate data to detect vicissitudes in extent of water bodies. This study discovered an extensive variation in water surface and vegetation of the Bolgoda area over a span of 09 years. It revealed that 6.95% percentage of water area significantly degraded due to various causes around the study area during past decade. As well as it also indicate 8.95% percentage decline of vegetation in the area at the same time. In contrast, it also revealed that 28.81% percentage of built up areas were expressively increased between the time periods. Rapid urbanization and development of study area during the past decades has posed a serious threat to the presence of ecological systems. There are identified numerous pressing problems in the Bolgoda area that could lead to decline of the quantity and quality of the habitat, such as cleaning of vegetation, specially mangrove areas for developmental activities, encroachment and illegal constructions , filling parts of wetlands for developmental activities , pollution from solid waste dumping, industrial effluents, household sewage and so on.

Keywords: Landsat, MNDWI, NDVI, NDWI, SVM

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Ceylon Cinnamon in US Market: An Investigation of Label Attributes of Ready to Eat Cinnamon Products

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Abstract

Mass level of recent food related issues and scandals generated a destructive energy towards the fast food and ready to eat industry by alarming the world about the food safety and security. Descriptive and informative food labels play a major role in nowadays consumer choice regardless of the regional barriers. Our approach is to identify the cinnamon based ready to eat products and sources in the US market and analyse the label attributes by concerning the positioning strategies of Ceylon cinnamon. The study was based on survey strategy concerning the US food and beverage market and online retails. 30 brick-and-mortar stores and 55 online platforms were used to capture the relevant data. Study identified six products categories available in the US market as well as three positioning strategies. Prominent strategy was mentioning the Cinnamon in front label where 3 common methods were identified; display only the name but not highlighted (26%), highlighted name placed in prominent place (centre of front package) (43%) and both name and the picture (31%). Breakfast cereal for kids, breakfast cereal for adults, cereal bars, bakery and confectionary, spice mixes and tea were the identified categories. Flavoured tea and spice mix recorded the highest nutritional values for the both Nutrition Profile Model (NPM) score and Nutrition Profile Index (NPI). Seven major Cinnamon based ready to eat product sources were identified and supermarkets frequently offer the cinnamon based products compared to the sources. Study identified that larger fraction of less NPI scored products were consumer friendly and the front label capable of manipulate the purchase decision rather than the high NPI scored products. Significant amount (98%) of product labels found in US retail market consist of Cassia image in the front positioning while none of the labels were used the image of Ceylon cinnamon as product strategy. None of the labels were not mentioned the Coumarin content and Ceylon cinnamon with its unique feature of ultra-low levels of Coumarin was not considered. Ethnic food stores, restaurants and supermarkets were the main retail market places and about 30 Ceylon cinnamon exporters were supplying Ceylon cinnamon to the USA market.

Keywords: Cinnamon, Food labelling, Label attributes, Positioning, US market

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Impact of Alternative Food Trends on Under Utilized Crop Value Chains: A Case of Sri Lanka

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Abstract
The world's food energy depends on only about 30 crop species whereas over 7000 species have been known to be used for food and are either partly or fully domesticated. This large portion of crop species known as underutilized crops. With health concerns, urbanization, income levels; the demand for underutilized crops was rapidly changed in both locally as well as globally. Present approach was to investigate the emergence of alternative food trends (Organic food, Chemical free, wild collected etc.) in local market and export market (ethnic market), to identify the impact on underutilized crop value chain actors; small scale farmers, middlemen, exporters and consumers and to find out the impact of alternative food trends on farming environment. Mixed method approach was employed and the sample size was 450. Farm households were selected from Uva and Eastern provinces. Key informant interviews, focus group discussions, interviewer administered questionnaires were used to collect data. Consumption of wild collected fruits and vegetables, chemical free, village food, organic food (certified and non-certified) and healthy food/functional food were identified as important alternative food trends in local market. In export market; demand was for authentic Sri Lankan food types. Nearly 50 different types of crops were identified in farmer level (was 60% vegetables, 30% cereals and pulses and 10% fruits) and best crops were recommended to each district based on the crop suitability index and developed a map of crop suitability. Informal collecting canters were common and 70% went as raw products to the market. These village level collectors link farmers and wild collectors with the upstream of the value chain. Middlemen were mainly responsible for collecting, marketing, transportation, storage as well as for huge post- harvest losses. Out of 50 exporters only 35 exporters were dealing with value added underutilized food products and they more concerned on safety and quality requirements. The main environmental issues identified were wild life threat, pest and diseases problems, changes in rainfall pattern, access rights and water scarcity.

Keywords: Food trends, Underutilized crops, Value chain

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A Study to Access the Compliance on Safety and Quality Standards: A Case of Pepper Value Chain

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Abstract

Sri Lankan pepper *(Piper nigrum)* is well known for its superior inherent property due higher piperine content and inherently rich oil and oleoresin content. Yet its exports are confined mainly for the Indian market where the market entry requirements were fragile. Sri Lankan pepper should explore the high-end markets to secure better returns to its value chain actors. Thus it was deeming appropriate to investigate on the compliance of pepper value chain actors on safety and quality standards and certification. This would help to identify the potentiality of Sri Lankan pepper to reach to high-end markets. The study was carried out in Matale, Kandy, Kegalle, Rathnapura and Badulla which were the main pepper growing areas. The sample consisted of 200 respondents including pepper growers, traders/collectors, and exporters. The data was collected though structured questionnaires, focus group discussions and in-depth interviews. The case study approach was adopted to study on each value chain actor. Further descriptive statistics were also used to analyse the study. The study revealed that the majority of the upstream growers and downstream exporters function independently and traders act as the dead bridge which links them together. Further, up and down streams behave defiantly on quality signals. Informal, unorganized, traditional upstream has marginally complied on quality signals due to inadequate awareness, lack of knowledge, training and skills development programs on food safety and quality in rural areas, high cost of investments for certification schemes, and access to technology. Prime concerns of the middlemen were profit orientation. Their attitudes and behaviour on safe and quality supplies were poor. The study revealed the exporters had a high compliance to quality and safety standards in contrast to farmers and the middlemen. However, the formal, organized downstream members were not maintaining healthy relationships with upstream. Thus, it is important to bridge the knowledge gap between the downstream and the upstream actors and to promote and establish a networking mechanisms for the institutions to share the responsibility to deliver effective services that could uplift the industry to sustain in highly competitive international markets.

Keywords: Food safety and quality, Pepper, Value chain,

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Production and Marketing Constraints of Coconut Cultivation in Kurunegala District

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Abstract

Coconut (*Cocos nucifera*) is one of the major plantation crops that plays a vital role in the Sri Lankan economy. Currently coconut production has dropped significantly comparison to previous years. This contraction in nut production affected adversely to local consumption and coconut related industries. In such context, this study was conducted as a case study to examine the production and marketing issues faced by the coconut growers and analyze gross market margins of coconut cultivation at Bingiriya and Pannala Divisional Secretary's Divisions in Kurunegala District. Primary data were collected from randomly selected 70 coconut growers by using a pre-tested structured questionnaire. Descriptive and inferential statistical tools were used to analyze the data. According to the kruscal-wallis analysis, it was identified four major production constraints which affect the coconut growers. Adverse weather condition was the most leading constraint while losses due to pest and diseases were the second main constraint. The third and fourth priorities were lack of proper management practices and land availability, respectively. The majority (94%) of the respondents have marketed their coconut production through intermediaries. The main constraint faced by the growers during coconut marketing was the high commission for intermediaries. The cost of coconut cultivation per acre was LKR 413040.00. Based on the gross margin analysis, highest producer share was reported for the channel which consists of the Producer- Wholesaler- Retailer- consumer (66.3%). This study suggested that it is vital to produce and introduce heat tolerant, pest and disease tolerant high yielding coconut varieties to the growers. Also it is important to enhance the farmers' accessibility to different marketing channels in order to obtain a higher profit.

Keywords: Coconut cultivation, Gross market margin, Marketing constraint, Production Constraint

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Assessing the Impact of Nutritional Labelling on Buying High Quality Dairy Products; A Case Study at a Galgamuwa Supermarket

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Abstract

Informational labeling can be viewed as a major attribute in determining the product quality. It can be categorized as an element of packaging which can be used to influence consumer buying behavior positively, either ethically or unethically. Recently, consumers' confidence towards high quality dairy products in the market becoming reduced due to various crises emerged in food retail industry. Therefore, the present study intends to assess the impact of informational labeling on buying high quality dairy products by a case study at a Galgamuwa supermarket. Main objective is to assess the impact of informational attributes of a product on consumer purchase intentions. A pre-tested structured questionnaire was used as the research instrument to collect data from the supermarkets. Most convenient supermarket in Galgamuwa DS division was selected as the study area and 200 consumers visiting supermarket at any time of shopping hours of 10 convenient consecutive days, while randomizing the time segments of shopping hours. Collected data were tabulated in spreadsheets and analyzed using Wilcoxon signed rank test. The results showed that both nutritional facts (Z= -9.040, p=0.000) and product facts (Z= -9.048 p=0.000) affect significantly on consumer buying of dairy product at 95% confidence level. Further the study revealed that the product facts such as method of storing (Z=6.892, p=0.000), country of origin (Z= -6.646, p=0.000), brand name (Z= -7.575, p=0.000), manufacturing and expiry dates (Z= -9.376, p=0.000), method of preparation (Z= -8.691, p=0.000), contact details (Z= -7.823, p=0.000), ingredients (Z= -8.780, p=0.000) and certifications (Z= -8.864, p=0.000) showed significant impact on assisting a consumer to purchase high quality dairy product from the supermarket. Current study recommends set managerial implications, to use concise of ethical information when designing a label for a dairy product to win customer confidence towards a specific brand and to view it as a high quality offering in the market place.

Keywords: Consumer buying, Nutritional facts, Product facts

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Assessment of Heavy Metal Contamination and Quality of Drinking Water Sources in Kamburupitiya, Sri Lanka; A Case Study in Lenabatuwa and Iiriyathota GN Divisions

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Abstract

For most households in Kamburupitiya area, well water and pipe borne water from springs are the major source of water supply for domestic consumption. In recent years the incidences of cancer and other digestive tract ailments were rapidly increased in this area. The relationship between the presence of heavy metals in drinking water and the prevalence of such diseases is very important. Hence, continuous monitoring of drinking water quality is essential to identify the chemical toxicity in terms of heavy metals. According to the statistics, the highest number of cancer patients was found in Kamburupitiya area especially in Lenabatuwa GN division during past few years. The Iiriyathota GN division has 4 natural springs in Iiriyathota. Two of these are used to distribute pipe borne water to most of the households in Kamburupitiya. Therefore, the main objective of this study is to assess the groundwater quality in terms of heavy metals. Water samples from three identified water sources which are domestic wells (W1-W10), lake (L1) and natural water springs (S1-S5) used by the locality for the drinking purpose were collected separately and their heavy metals (Cu, Cd, Pb, Zn, Fe, Ni, and As), pH, electric conductivity, and total dissolved solids were chemically analyzed by using standard methods. The data were analyzed statistically. The results revealed that the drinking water quality is not according to the WHO standards. Heavy metal content also higher than WHO standard and some samples contained higher amounts of Pb, As and Fe and was exceeded permissible levels. According to the results, the average concentration of heavy metals such as Cu, Cd, Pb, Zn, Fe and As were 0.017 ppm, 0.001 ppm, 0.014 ppm, 0.009 ppm, 0.163 ppm and 0.004 ppm respectively. The pH level was very low in all domestic wells and in one water spring (S1) which was below the recommended level of 6.5-8.5. Therefore, overall low pH in majority of the samples and high level of heavy metals in some samples could impose a threat to human health. Therefore, it is recommended for a routine monitoring in potable water sources in the study area to examine its suitability for drinking purposes.

Keywords: drinking purposes, heavy metals, permissible level, water quality

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Impacts of Tourism on Rural Livelihood in the Sustainability of an Ageing Community in Japan

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Abstract
Rural tourism, which is often considered as rural development initiatives, has been extensively studied in Japanese context, however, usually observed at a community level, and supposed that host households were homogeneous. The article added to established literature by studying how rural tourism, contributes to sustainable livelihoods at household level in an ageing community in a developed economy. For this purpose, a qualitative study was conducted in a farm inn group in Noto town, a Globally Important Agricultural Heritage System (GIAHS) site in Japan. We tested three hypotheses: 1) rural tourism in a remote/isolated region has changed the livelihood assets of host households; 2) the economic benefits from rural tourism is marginal to host households; and 3) the benefits other than income earning exceeds economic benefits for ageing communities. Generally, host communities have improved their livelihood assets through farm inn business. The residents' life quality has been improved in this super ageing rural, although, economic benefits are still marginal to majority of the host households. Tourists have brought vitality to these remote villages. The lacking of young residents and inherits of their farm inn business is a bottleneck to its future development. The social capital should be strengthened through forming a social network with local government, as well as private sectors.

Keywords: Agricultural heritage, Community participation, Farm inn, GIAHS, Livelihood assets, Rural development

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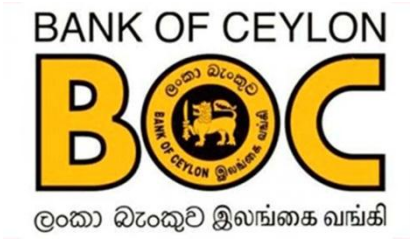

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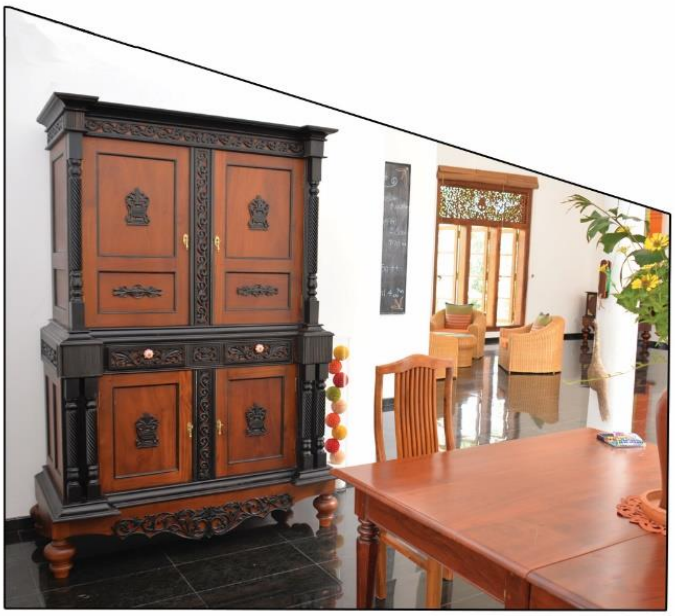

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