PROCEEDINGS OF THE 5th INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE (ICDA 2019)

"Towards Green and Blue Food Security"

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Message from Dignitaries

Message from the Competent Authority, University of Jaffna

Emiratus Prof. K. Kandasamy
Competent Authority
University of Jaffna
Jaffna 40000
Sri Lanka

I am greatly honoured and privileged to be a part of the 5th International Conference on Dry Zone Agriculture (ICDA) 2019, an esteem event hosted by the Faculty of Agriculture, University of Jaffna. Since its inauguration, the Faculty of Agriculture has been working on the coexisting problems connected to the field of agriculture producing highly competent graduates to assist the people in general and specially farmers.

Organizing International Research Conference is noteworthy to gather eminent scientists from around the world in all discipline related to the Agriculture and to give them a podium to share their verdicts with other researchers. The theme of the ICDA 2019 "Towards Green and Blue Food Security" explains the significance of the crop production for the world food security as well as the significance of the aquatic agriculture to fullfill the food requirement of the universe. This conference also provides a unique opportunity for agricultural experts, users and other researchers to meet, discuss the status of the research in agriculture for food security and focus both on future needs and on the requirements to meet those needs.

I take this opportunity to acknowledge the dedication and commitment of the Dean of the Faculty and staff members, especially the organizing committee of ICDA 2019 for their untiring efforts for making this an outstanding event.

I wish to convey all the good wishes for ICDA 2019.

Message from the Conference Chair

Dr. K. Sooriyakumar
Dean/Faculty of Agriculture
University of Jaffna
Ariviyal Nagar, Kilinochchi
Sri Lanka

On behalf of the Faculty of Agriculture, I warmly welcome you to the 5th International Conference on Dry Zone Agriculture (ICDA 2019). It is indeed a privilege and pleasure to deliver this message as Dean of Faculty of Agriculture and Conference Chair on the 5th International conference on Dry Zone Agriculture 2019 scheduled to be held on 19th and 20th December 2019. I consider this as one of the most important events in the faculty calendar. As in previous years, ICDA 2019 provides an excellent forum to bring researchers from different disciplines to a common platform to disseminate their findings, exchange knowledge and ideas and build partnerships on variety of topics.

The theme of this conference is "Towards Green and Blue Food Security". Production of food of animal origin is a very complex and selective consideration. A cooperation of animal scientists with scientists working in the fields of plant and feed science, ecology and economy seems to be necessary to achieve green and blue food security and to develop better and loadable land footprints. More feed for more people with less resources and emissions is one of the important challenges for all those involved in green and blue food production.

The ICDA 2019 includes a range of inspiring keynote addresses from eminent scientists and scholars. On behalf of the Faculty of Agriculture, I wish to express my profound gratitude to the Competent Authority, Professor Kathirkamanathan Kandasamy for his enormous support. Let me also take this opportunity to thank all our Guests, Plenary speaker, Keynote Speakers, Chair of the sessions, Sponsors and Members of organizing committee as well as everyone who helped in numerous ways to make ICDA 2019 a success.

While warmly welcoming all delegates to ICDA 2019, I hope that participation at ICDA 2019 will be a rewarding experience to them.

Message from the Convener

Dr. (Ms). Loha Pradheeban
Head/Department of Agronomy
Faculty of Agriculture
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Ariviyal Nagar, Kilinochchi
Sri Lanka

It is my honour to welcome you all to 5th International Conference on Dry Zone Agriculture (ICDA 2019). This event is one of the prides of Faculty of Agriculture, University of Jaffna. Since establishment of the Faculty in 1990, we underwent many hardships and now have settled in Ariviyal Nagar, Kilinochchi. Now we are strengthening our Faculty and one of such event is ICDA.

The theme of this year's ICDA 2019 is "Towards Green and Blue Food Security". This is a two days event involving twelve technical sessions which will provide the audience enough opportunity for discussions and networking. The presence of international experts boosts the knowledge of researchers from all over the Island.

I take this opportunity to extend warm welcome to the resource persons and delegates registered for the conference. I hope that all participants have an memorable stay in Ariviyal Nagar, Kilinochchi.

Message from the Finance Chair

Prof. (Ms). T. Mikunthan
Dept. of Agric. Engineering
Faculty of Agriculture
University of Jaffna
Ariviyal Nagar, Kilinochchi
Sri Lanka

It is with great pleasure and privilege to give the Finance Chair's message to the proceedings of the 5th International Conference on Dry Zone Agriculture 2019 (ICDA 2019) of Faculty of Agriculture, University of Jaffna, Sri Lanka. The objective of the proceeding is to publish up-to-date and high quality research findings, focusing all aspects of agriculture in the dry zone of Sri Lanka.

The successfulness of the ICDA 2019 is supported by the sponsors. I would like extend our sincere thanks to our University Research Committee (URC) and WaSo Asia Project for providing financial assistance to covering up the expenses related to printing of faculty journal volumes and ICDA 2019 Conference proceedings. I also would like to express our heartfelt appreciation to Co- Sponsors; A.Baurs & Co, Analytical instruments, E.S.P. Nagaratnam & Co and Pirakanth Photo copy centre. We sincerely hope that this association will be maintained and you will continue to support us in our future endeavors.

I would like to thank the contributions made by the authors, reviewers, editors and the editorial board for their tireless efforts to release proceedings in time. I take this opportunity to thank everyone who supported for the success of the proramme.

Message from the Conference Secretaries

Mr. G. Asharp Sharmec
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As the Joint secretaries of the 5th International Conference on Dry Zone Agriculture (ICDA)-2019, we extend our very warm welcome to all of you to this special occasion, at the Faculty of Agriculture, University of Jaffna, Ariviyal Nagar, Kilinochchi, Sri Lanka. As an integral part of the conference, it has been a great honour and privilege to serve as the secretary of the conference this year.

ICDA-2019 provides international forums for researchers from academia and industries to exchange and share their experiences, research findings, and new ideas on hot and emerging topics in Agriculture. This year we enjoyed the great privilege to have worked with researchers across the world covering a variety of topics. The conference theme "TOWARDS GREEN AND BLUE FOOD SECURITY" well suits today's needs, where each and every person living on the earth totally depend on the needs of healthy foods and beverages. Thus, the scientist should disseminate the latest innovations not only to the colleagues but also with the farming community to sustain the food production along with the climbing global population. ICDA is one of the great platform for the academics, students and farmers to grab needful theories and practical concepts from the esteem scientist which motivates the audience to implement these findings in their real field.

Many people have contributed to the ICDA 2019. We would like to thank the authors who expressed interests and submitted their papers to the conference. Their efforts have been the driving force of this conference. We would like to express our deepest gratitude to the panel of reviewers, who provided timely reviews for the papers despite the tight schedule. We wish to thank our Chief Guest Prof. K. Kandasamy, Competent Authority, University of Jaffna and the Conference Chair and Dean/Faculty of Agriculture, Dr. K. Sooriyakumar for their kind support and guidance. We also would like to thank our Guest of Honour, Plenary Speaker, Keynote Speakers, Presenters and Participants for their valuable time and support. At this juncture, it is necessary to extend our special thanks to the Staff/Faculty of Agriculture and the organizing team of the ICDA-2019, in particular Convener, and Financial Chair for their outstanding leadership. To summarize, we are sincerely appreciative to all who have supported us and contributed to this conference in one way or the other. This event would not have been possible without them.

We hope every one of you will enjoy your time at the conference.

Address from the Professional Excellency

PLENARY ADDRESS

Value Chain on Industrial Agroforestry in India: A PCS Approach for Sustaining Raw Material Security and Mitigating Climate Change

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INTRODUCTION

Forests in India have played a significant role in meeting the domestic and industrial wood requirements before the enactment of Forest Conservation Act (1980) and the National Forest Policy (1988). Owing to policy and legal implications, there has been a paradigm shift in the forest management strategy of the country with more emphasis on conservation oriented management which resulted in restricted supply of wood from natural forests India being one of the major consumers in the Asia Pacific region, it is estimated that the country would need 152 million m^3 of wood by 2020. This demand has been estimated for 12 organized wood based industries and does not include the fuelwood demand of the country which is also on the rise.

In 2010, world's agricultural lands occupied 4889 Mha, an increase of 7 % (311 Mha) since 1970 whereas agricultural land area has decreased by 53 Mha since 2000. Increasing wood demand coupled with changes in land use pattern have necessitated significant interest towards agroforestry, a landuse system which is being practiced across the country in various forms since time immemorial.

Though agroforestry is an age old practice as an important form of subsistence farming, in the recent past, it is valued as a commercial and profitable land use system across the world. Approximately, 1.2 billion people (20 percent of the world's population) depend directly on agroforestry products and services in rural and urban areas of developing countries. Agroforestry systems are superior to other land uses at the global, regional, watershed and farm scales

since they optimize tradeoffs between increased food production, poverty alleviation and environmental conservation.

The current area under agroforestry is of the order of 400 Mha, of which 300 Mha are "arable lands" and 100 Mha are "forest lands". It is estimated that an additional 630 Mha of croplands and grasslands could be converted into agroforestry, primarily in the tropics. FAO has also emphasized that agroforestry must be integrated in the Clean Development Mechanism (CDM) to broaden the scope of agroforestry. In India, several traditional agroforestry systems are successfully established with the tree-crop combinations like home garden, Silviagriculture, Silvipasture, Plantation crop based agroforestry, wind break, shelterbelts, *etc*., which attest the significance of agroforestry in India.

Recognizing the growing importance of agroforestry, the Indian Government directed the wood based industries to generate their own raw material in the National Forest Policy of 1988. However, policy directives were not taken seriously by many wood based industries barring a few exceptions. Growing demand for wood and wood products and legal issues in wood supply from Government owned natural forests ushered in a total mismatch between demand and supply of wood and wood products.

Under such circumstances, Tamil Nadu Agricultural University (TNAU) conceived and implemented "A Value Chain on Industrial Agroforestry" to create sustainability in raw material generation by involving a wide range of stakeholders. This model of Industrial Agroforestry was implemented between 2008 and 2018 which witnessed successful establishment of over 80,000 ha of organized Industrial Agroforestry plantations. To sustain the positive impacts generated by this value chain model, an institutional mechanism called "Consortium of Industrial Agroforestry" (CIAF), was established which is first of its kind in the country and addresses the issues related to production, processing and consumption in Agroforestry. Further the institution has been strengthened by establishing India's First Agroforestry Business Incubator which caters to the need of Business Development in Agroforestry sector. In a holistic perspective, the value chain in Agroforestry is a lucrative model for ensuring raw material security besides acting as an alternate land use system to mitigate climate change and has an excellent replication potential across the tropical countries.

AGROFORESTRY–CONSTRAINTS AND INTERVENTIONS

The wood based industries in the state of Tamil Nadu, India have been interacted for ascertaining the exiting supply chain system. Based on the interactions and the consultations with the industries, tree growing farmers, non-governmental organization involved in promotion of agroforestry and other stake holders, Forest College and Research Institute of Tamil Nadu Agricultural University has identified several constraints towards promotion and popularization of agroforestry. These constraints have been grouped into three levels *viz*., production related constraints, processing associated constraints and the consumption related constraints.

INTERVENTIONS THROUGH VALUE CHAIN APPROACH

The constraints identified in the entire Production to Consumption System (PCS) in Agroforestry have been resolved through strong research and development mechanism coupled with the associated supply chain process. The entire PCS based industrial agroforestry has been value added through innovative technologies resulting in massive industrial agroforestry development in association with several wood based industries. The interventions have been done through technology development, organizational linkage and facilitating market support system in association with respective wood based industries which are briefed below:

1. Development of HYSR Clones

One of the major breakthroughs in promotion of industrial agroforestry is the development of High Yielding and Short Rotation Clones (HYSR) particularly for pulp, paper, match splint, dendro power and plywood industries. The HYSR clones developed in Casuarina, Melia, Kadam, Sissoo, Eucalyptus, Mahogany, Morus, Toona *etc.* have created significant Productivity impact which ranged between 25 m^3/ha/annum and 50 m^3/ha/annum.

2. Mini Clonal Technology

Development of mini clonal technology for most tree crops has ensured availability of quality planting materials in a required quantity and period. This technology has eliminated epigenetic variation, ensured clonal fidelity with improved productivity. Above all, the rapid multiplication process with limited space and period has attracted this technology for adoption by all levels of stake holders

3. Precision Silviculture

Replacement of traditional silvicultural systems with precision management practices like optimal espacement, drip fertigation management coupled with systematic tending operations have led to improvement in productivity and wood quality.

4. Multifunctional Agroforestry

Cogeneration of wood and food in the same unit of land is the major success of Industrial Agroforestry in India. Incorporation of HYSR clones with agricultural, horticultural and grass components has ensured sustained income and employment generation activities particularly for small and medium farmers.

5. Value addition Technology

One of the major technological interventions in Industrial agroforestry is the development of value addition process for both forestry and agricultural residues. It is estimated that 1 ha of Industrial Agroforestry plantations is able to generate 5-10 tonnes of plantation residues which are either unutilized or underutilized. This issue has been resolved through value addition process which led to production of pellets, briquettes, activated charcoal, feed pellets, particle board *etc*. and extended additional revenue to the farmers and development of new value addition industries.

6. Mechanization

The entire Production to Consumption System in Agroforestry has been facilitated through suitable mechanization process which resolves the issues of labour crisis, human drudgery, efficiency improvement and the issues related to felling and conversion.

7. Price Supportive System

The most significant attraction of Industrial Agroforestry is extending price supportive system for farm grown trees in association with respective wood based industries. Initially the price supportive mechanism has been extended through pulp and paper industries which attracted promotion of pulp wood based Industrial Agroforestry. The price supportive system coupled with assured buy back has attracted more stake holders towards tree husbandry. This price and buy back support system has been extended now to timber, veneer and ply wood, dendro power, match splints and packing case industries which lead to intensive promotion of Industrial Agroforestry

8. Insurance Mechanism

The agroforestry plantations have witnessed damages due to both biotic and abiotic factors due to the growing climate change associated risks and uncertainties. This has resulted in huge crop and income loss to the farmers which have been resolved through implementation of comprehensive tree insurance mechanism for major industrial wood species. The perils included all the damages due to abiotic and abiotic factors and the premium is fixed at the lowest level of 1.25 % of the input cost.

IMPACT OF THE VALE CHAIN SYSTEM

The value chain model conceived and implemented for industrial Agroforestry plantations have made significant impacts which are discussed.

1. Area Expansion

The interventions made through technological, organizational and marketing system have attracted intensive implementation of Industrial Agroforestry plantations both by the farmers and the wood based Industries. The last one decade of value chain based Industrial Agroforestry promotion has witnessed establishment of over 80,000 ha of Plantations and extended sustainable supply of raw materials to the various wood based Industries and translated unutilized fallow land into productive plantations.

2. Productivity impact

The value chain system has made tremendous impact in the productivity of plantations which has been enhanced from the base line status of 10 m^3/ha/annum to the tune of 25-50 m^3/ha/annum and ensured doubling the productivity of land use system.

3. Economic impact

Due to the productivity impact, the income generated from the land use system has been enhanced triple times with a BC ratio of 1:3.5 and above depending on the species deployed and the associated industrial utility.

4. Increased Participation of Industries

Initially the value chain model was implemented only with two pulp and paper industries which has now attracted over thirty wood based industries which included timber, veneer and plywood, particle board, match splints, dendro power, packing case and several value addition industries which ensured successful adoption of the Agroforestry value chain system.

5. Environmental impact

The industrial Agroforestry plantations has been analysed for its environmental impacts and it is clearly evident that these plantations have made significant contribution towards carbon sequestration. The C sequestration potential of Casuarina, Eucalyptus, Ailanthus, Melia, Kadam *etc.* have been assessed and it is estimated that on an average 50 mg of Carbon is sequestered from 1 ha of plantation. The entire plantation made through this Industrial Agroforestry plantation has sequestered 4 million mg of carbon which has benefitted the environment and created a clean developmental process. Promotion of dendro biomass based energy generation process also ensured clean and green energy generation.

SUSTAINABILITY AND WAY FORWARD

The growing demand for wood and wood products and reducing supply from natural forests have demanded sustainability plan to ensure raw material security and to stabilize the ecosystem and the environment. Hence the scientific team has conceptualized and established value chain system coupled with an Institution called Consortium of Industrial Agroforestry which has linked all stake holders involved in the entire Production to Consumption System. The issues involved in production to consumption system of Agroforestry have been resolved by the Consortium both locally and regionally. Further the scientific team has established India's first Agroforestry Business Incubator which caters to the need of skill development and involved in creation of start- ups, entrepreneurs and new industries which ensured sustainable income and employment generation opportunities. This model of Industrial Agroforestry value chain and the associated consortium and incubator development has a very good replication potential across Asian countries for productivity and profitability improvement besides acting as an alternate land use system for mitigating the growing concerns on climate change. This demand Institutional and Industrial linkage across different nations to ensure successful implementation of value chain process through Agroforestry.

KEYNOTE ADDRESS

Growth of Poultry Industry Towards Export Market

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INTRODUCTION

Poultry industry is identified as the most important livestock sub sector in Sri Lanka contributing to 0.36 % GDP in 2018. Over the last 20 years the industry has shown significant growth with the chicken meat production of 52.8 (000 MT) in 1998 to 214.2 (000 MT) in 2018 and the egg production of 730 (Mn) eggs in 1998 to 2853 (Mn) eggs in 2018. Consequently, the per-capita consumption of chicken (2.9 kg at 1998 and 9.7 kg in 2018) and eggs (40 eggs in 1998 and 131 eggs in 2018) too have increased substantially and stand as a socially and economically acceptable animal protein source for all ethnic, religious and social groups. These products have reached the stage of demand sufficient and currently explore the export market.

Poultry industry is dominated by the private sector and supported by the government by regularizing and facilitating its operation at optimum level. Almost 100 % of small-scale broiler farms (<5000 birds) are operated as buy-back or out-grower farms of large-scale commercial operators. However, layer farms operate individually. The backyard poultry rearing is a common development program encouraged by the government to support rural poor to uplift family income while supporting nutrition. Genetic upgrading, modern farm management practices with mechanization, high biosecurity and poultry health management, advances in feeding and feed production are identified as the pillars of the growth of the industry. Feed manufacturing, meat processing and further processing, veterinary pharmaceuticals and equipment supply are other co-industries which mutually dependent and parallelly grown. The contribution of these industries to the national economic growth and

generation of employment through poultry industry will increase the real economic contribution of the poultry industry much more than the presently declared GDP.

GENETICS AND BREEDER OPERATION

The commercial broiler strains are genetically improved for faster meat production and the presently available strains have the ability to achieve 2.0-2.2 kg body weight in 30-35 days under general management practices. The Broiler Grand Parent (GP) farms (3 in number) with imported GP birds produce 85 % of the requirement of parent chicks in the Broiler Breeder Farms (34 in number). These are of Cobb, Hubbard, Indian River, Ross and Arbor Acres. There are no Layer GP farms and therefore all eight Layer Parent farms import the Parents as day old chicks. Present strains produce 375 to 400 eggs in 90 weeks with 72 weeks production cycle. They are of white strains of Bovans, Dekalb, Lohmann and Hyline. Under the power vested through Animal Diseases Act No 59 of 1992 the Department of Animal Production and Health (DAPH) regularize and facilitate the operation of Poultry Breeder Farms and hatcheries by registration with annual renewal. Thereby the health management practices and biosecurity measures are ensured to appropriate level so that the day-old chicks for commercial broiler or layer operation are produced with adequate standards and are free of disease-causing agents.

FEEDS AND FEEDING PRACTICES

All the Animal feed manufactured in the country are regulated by the DAPH under the power vested through Animal Feeds Act No.29 of 1958 and Animal Feeds Act (amended) No.12 of 2016. Major feed manufacturers have the mills where the entire process is mechanized. 95 % of the animal feed produced in the country are used for poultry. Most of the feed raw materials are imported since they are not locally produced or even if produced not in adequate quantity. Importation of these ingredients especially the maize is always controlled and it is identified as a major constraint on the development of the poultry industry. Other main feed ingredients including Soy bean meal supply also depend on importation. As such the feed cost is always affected by the inflation.

MARKETING AND SERVICE DELIVERY

Poultry marketing chain is well organized and in most of the time the Breeder Farms require a standing order to be placed 1-2 years in advance to receive the day-old commercial chicks. Broiler market is dominated by larger producers integrated from parent day-old chick production to the marketing of processed chicken meat. They also operate out-grower or buy-back system where the inputs such as day-old chicks, feed, vaccines, medicines, veterinary

service and extension services are provided to farmers and birds are bought back on pre agreed price for the live weight after 30-35 days. Market price is basically governed through the supply and demand and very little variations in the price observed on the brand, packaging and marketing facility.

Most of the chicken meat is supplied through the organized chicken meat processing sector and a small proportion is provided by the informal ways such as live bird or wet markets. Currently there are 15 large-scale poultry processing establishments operate in the country and ensures the provision of high-quality hygienic meat to the consumer. They have established quality assurance systems for processed meat production with Sri Lankan Standards (SLS), ISO and HACCP standards and supply the chicken meat through their own marketing network or supermarkets.In layer industry, the Breeder operation to egg marketing is integrated in large scale commercial egg producers. The marketing price is centrally determined by organizations of egg producers and egg marketers. Large scale producers have obtained quality certification such as ISO, GMP and HACCP. Well packed graded eggs are marketed through supermarkets at high price and value addition such as golden yolk egg & omega rich eggs are becoming popular among selected consumers.

FUTURE PROSPECTS

Poultry is the fastest growing livestock industry in the country with high-level technical capabilities and the demand for space, labour and capital requirement to expand this sector is much low compared to other livestock industries. Chicken egg and meat are scientifically proven and widely accepted as healthy food of animal origin. Moreover, the prices of these commodities are relatively inexpensive compared to other food of animal origin. As such chicken meat and egg could play a major role in eliminating protein malnutrition which is a common problem among growing children and females in the population.

Quality of chicken meat and eggs with special emphasis on food safety is increasingly becoming as a future challenge in poultry production. Strengthening of biosecurity and mechanization of farm operation with good animal husbandry practices will reduce the disease occurrence and antibiotic use in poultry production. Use of therapeutic antimicrobials and antibiotic growth promoters as feed additives have already been banned in the country as a way to reduce occurrence of antimicrobial resistance (AMR). Mitigation of occurrence of foodborne infections through hygienic production of animal products are encouraged by advocacy of stakeholders. It is anticipated to introduce the value chain quality certification system to further strengthen the food safety mechanism in near future.

Sri Lanka is one of the few countries in the world which has remained as free of highly pathogenic avian influenza (HPAI) which is one of the major zoonotic disease of avian infection. This disease- free status is maintained continuously by adhering to strict quarantine measures at importation of birds and other related risk materials combined with the establishment of early warning system via active disease surveillance at hot-spots of migratory bird locations and their vicinity. This situation provides the opportunity to explore the export market of poultry products which has already been looked into by the private sector as a new venture in the future. This has been duly recognized and identified as an area for the government authority to facilitate and strengthen the growth of poultry industry in the country.

KEYNOTE ADDRESS

Role of Agricultural Policy towards Agri-Food Sector Modernization: What We Can Learn from a Comparison of Local vs. Global Policies

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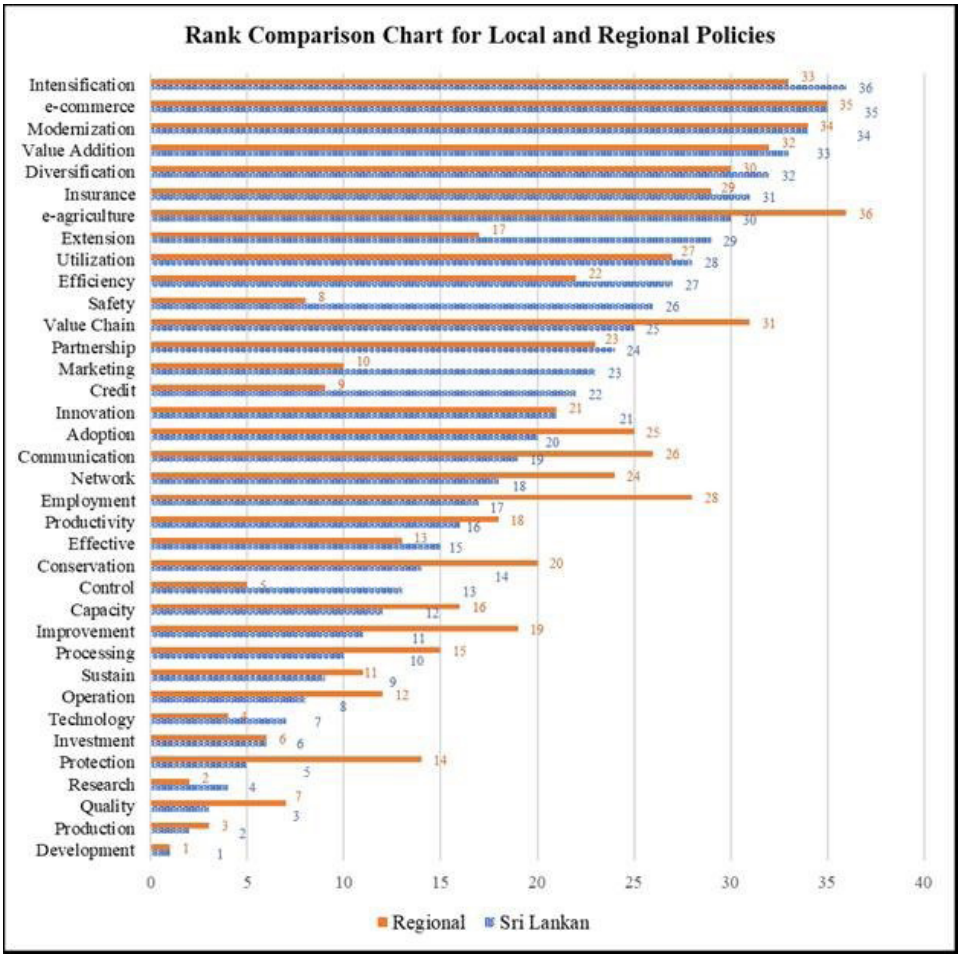
Economic and management theory suggest two broad strategic options, *i.e*. 'Private/Market Actions' and 'Public/Statutory and Regulatory Approaches' can drive a social system to carry out its "job" as stipulated. However, it is of paramount importance that such actions/approaches are well documented within a framework of policy to facilitate implementation. Empirically, we can see that conventional wisdom has been placed more faith towards the role of 'government', compared to the 'market', to look after concerns of the society.

The principle justification for public policy intervention lies, thus, in the shortcomings of market outcomes. Yet, the rationale is only a 'necessary', but not a 'sufficient' condition for government policy. This highlights the value of deeper analyses into different policy arena, and in turn, the outcomes of which to be compared with the same in the global context to provide appropriate remedies. What has happened in Sri Lanka in this regard, and in fact, "what went wrong" with our policy, in general, and agricultural policy, in particular, is, therefore, of paramount importance to investigate for. An attempt was made, through a Content Analysis, to explore extent to which the 'local agricultural policies' are compatible with those of global. A formative review of literature covering the most highlighted agriculture-related policy documents in Sri Lanka (Local = 196) was undertaken in which the appearance of a set of 36 key policy terms were of interest[1].

1 Adoption, Capacity, Communication, Conservation, Control, Credit, Development, Diversification, E-Agriculture, E-Commerce, Effective, Efficiency, Employment, Extension, Improvement, Innovation, Insurance, Intensification, Investment, Marketing, Modernization, Network, Operation, Partnership, Processing, Production, Productivity, Protection, Quality, Research, Safety, Sustain, Technology, Utilization, Value Addition, Value Chain

These policy documents were, in fact, catalogued into 10 major categories, vis-à-vis: Credit and Finance policy, Environment policy, Food policy, Institutional policy, Land policy, Livestock and Fisheries policy, Marketing policy, Price policy, Research and Educational policy,

and Trade policy. Parallel to this inquiry, agriculture-related policy documents from Global context were under scrutinization for the same set of key terms and policy categories, where 150 documents were taken into account from 15 different countries, including 08 developed countries (Australia, Canada, China, France, Germany, Japan, United Kingdom and United States) and 07 developing countries (Bangladesh, India, Pakistan, Indonesia, Malaysia, Philippine and Thailand). The figure showing outcome of relative rank obtained by a given key term in relation to the Local and Global policies is given below.



If a policy document shows the highest occurrence of a key term, it is claimed that the particular document has been intensified with the corresponding area. For an example, local policy documents have contained the term 'Production' in higher frequency. It revealed that, nowadays policy formational institutions focus on incorporating development related policies into policy regulatory frameworks. In global policy documents, the terms 'Development', 'Research' and 'Production' were appeared in high frequencies. This ascertains that those countries have paid attention on novel technologies and innovations through research than in Sri Lanka when they come up with policy formations.

According to the rank comparison chart, the lowest rank in local policy documents has been obtained by 'Intensification', 'e-Commerce' and 'Modernization'. In global policy documents, the lowest frequency showed for 'e-Agriculture', 'e-Commerce' and 'Modernization'. Local policy forming institutions/agents have not paid much interest on novel technologies of the corresponding area discussed through the policy documents. Surprisingly, regional policy documents have not contained innovative technology related terms. Even though these countries are engaged in e-agriculture, e-commerce and modern agriculture in compared to Sri Lanka, it reveals that these practices have not been executed through (mandatory) regulation!

The vast difference in frequency of key terms among local policy documents showed for 'Development' and 'Intensification', where the former has been ranked first and the later was placed at the thirty sixth. In the local scenario, policy making bodies have paid their attention more on development because novel policies may have evolved on national development since it is the paramount importance of the country. Since the term 'Intensification' was the least appeared term, it suggested that, often policies are emerged for executing new ideas and intensifying existing policies are very seldom. Similarly, in global policy documents, the term 'Development' was ranked first. It is obvious that developed nations achieved their national development through converting their policies into a reality. Though e-agriculture is a common practice in most of the regional countries that term has been appeared rarely.

When comparing both local and global policies together, term 'Safety' ranked at eighth in regional policies, while it was ranked at twenty sixth in local policies. Results claimed that, policy documents in global level have incorporated food and agriculture related safety matters for their policies more, since they occurred in high frequencies compared to local policies. Apart from that, the term 'Marketing' showed a considerable difference in frequencies between local and global policy documents. It was appeared in high frequency in regional policies. It is clear that, respective policy forming bodies

at global level have taken responsibilities to regulate their marketing channels efficiently. However, term 'Credit' has not been occurred frequently in local policy documents though credit facility extension is a major component in Sri Lankan agriculture. It gives an impression that government credit principles have not been well-defined through policies.

As results suggested, same ranking was observed for 'e-Commerce', 'Modernization', 'Innovation', 'Investment' and 'Development' in both local and global policy documents suggesting the fact that similar pattern of evolving these policies is possible in both local and global policy documents. When comparing these frequencies further, it revealed that, there may be a mechanism of addressing, omissions occurred in the country level. Because, terms that give a sense of necessity of having corrective actions have not been appeared in very frequently in local policy documents. For an example, Sri Lanka is a developing nation and necessarily should focus on intensification, diversification and value addition etc. Since they have been appeared in lower frequencies than global policies, they have lower ranks than in regional countries and it reveals the necessity of scrutinizing these areas through policy documents.

Though credit is a greatest provision in extension services, an unwarranted credit extension tends to harm both debtors and creditors and in national level it a huge burden to the treasury. Thus, specific policies need be evolved to disseminate knowledge of credit principles and sound credit practices for proper and best utilization of credit. Throughout this study, it is highlighted on the keen in execution of specific policies on credit control and monitoring system for efficient functioning of the country.

Association between researchers and decision-making bodies have been considered a crucial factor in knowledge transfer processes. Results claimed that, considerable effort has been made to intensify the interaction between researchers and decision-making bodies. Because it reflects mainly through the findings of the researcher and the reception of the decisions-making body. More policies have been stated on research polices and it offers a clear and indulgent pathway for research and inventions. Government intervention is most important for upstream and downstream operations in marketing channels since there are some inefficiencies within those marketing channels. It is obvious that still those loopholes have not been addressed well through responsible authorities.

All these suggest in broad, that the agriculture sector is not rely exactly on sector-specific characteristics and it is based on supportive, predictable

and structural policy settings. Quality of production, credit facilities, strong market institutions, well-functioning financial markets and innovation systems are essential for sustainable development of the agriculture sector. All these key areas should be addressed through policy implementations and it will create the conditions for the development of the sector itself. Food policy settings also need re-alignment to since food security is foremost importance in local and global level. Sri Lanka is a country that is lacking on-availability of production and marketing credit, non-availability of transport, lack of information, low bargaining power due to lack of farmer organization, lack of adequate storage etc. These complications should be addressed specifically through policy regulatory institutions. In regional level, those countries have developed infrastructure for perishable agricultural products under government assistance. Sorting, cleaning, packing, transporting and storing are carried out systematically.

Further, they are working hard to uplift farmers bargaining power by way of group marketing and avoid unnecessary middlemen from the process. Different types of policy have been evolved in varying degrees in both local and global level, while some policies have not been coordinated properly. The absence of policy coordination can affect environmental and economic outcomes. When countries have to address distinct issues, the use of multiple policy instruments has considerable potential to solve national level complications. Further, policy formation processes should be customized since policy designs depend on policy practices, institutional capacity and other national circumstances.

We may, therefore, contend that neither market nor government alone is capable of directing a business, in general, and agribusiness, in particular, to develop a sound business environment to cater into their clients through its own action, and as a result, an appropriate institutional arrangement should be designed that joins all social institutions to augment the individual incentives possess by these agents to work with such institutions. My view is that this would be the 'point of rationale' for moving into alternative institutions where the notion of entrepreneurship has a role to play in agriculture (*i.e*. Agripreneurship) at everywhere possible level, including the market, government and judiciary.

KEYNOTE ADDRESS

Mycotoxin Risk on Food Products in Asia and Its Mitigation Strategies

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INTRODUCTION

Mycotoxins are toxic secondary metabolic products of moulds present on almost all agricultural commodities worldwide. Currently around 400 mycotoxins have been reported. These compounds occur under natural conditions in feed as well as in food. Some of the most common mycotoxins include: aflatoxins, trichothecenes, fumonisins, zearalenone, ochratoxin and ergot alkaloids (Grenier and Oswald, 2011).

Asia contributes a very large part of the globe with most developing countries in the tropical and subtropical regions. Considering the environmental conditions in these countries with warm and humid climate, agricultural commodities are particularly susceptible to fungal contamination and hence mycotoxins accumulation. Research and monitoring on mycotoxins are relatively limited comparing to western countries. There is very little information with regard to the extent of the mycotoxins problem in Asia. The actual situation of mycotoxins contamination is not known in this region. In recent years, rising number of survey with regard to prevalence of mycotoxins has indicated the seriousness of mycotoxins problem among Asian countries (Anukul *et al*, 2013).

OCCURRENCE OF MAJOR MYCOTOXIN CONTAMINATION IN ASIA

Mycotoxins such as aflatoxins, ochratoxins, fumonisins, deoxynivalenol and zearalenone are considered to be of particular concern in relation to human and animal health. Contamination of agricultural products by mycotoxins has become an important issue worldwide over the last three decades. Asia

contributes a very large part of the globe with most developing countries in the tropical and subtropical regions favouring the growth of fungal species. There is a high potential of mycotoxin occurrence and a number of important mycotoxin outbreaks in Asia.

Mycotoxins are extremely diverse groups of biological compounds that are toxic to vertebrates in low concentration. Mycotoxins can be classified as hepatotoxic, nephrotoxic, immunotoxic, neurotoxic and so forth according to the target organs or as mutagenic, carcinogenic, teratogenic, estrogenic. Individual mycotoxin can target various organs and elicit diverse biological effects. Mycotoxin producing fungal species are ubiquitous that are able to grow on various substrates under suitable temperature and humidity conditions. They have a strong ecological link with human food supplies (Pitt, 2000). Humans expose to mycotoxins typically via dietary exposure to contaminated food and its derived products. Global occurrence of toxigenic fungi and globalization of crop trade greatly contribute to worldwide mycotoxins exposure nowadays (Altomare *et al*., 2007). Aflatoxins (AFLs), ochratoxin A (OTA), fumonisins (FUM), deoxynivalenol (DON) and zearalenone (ZEA) are the mycotoxins of worldwide importance and monitored by Asian countries nowadays.

Aflatoxins are a type of mycotoxin produced by *Aspergillus* species of fungi, such as *A. flavus* and *A. parasiticus* (Martins *et al*., 2001). Aflatoxin B1, the most toxic, is a potent carcinogen and has been directly correlated to adverse health effects, such as liver cancer, in many animal species (Martins *et al.*, 2001). Typically, regulatory standards set by the Codex specify 15 µg/kg for total aflatoxins in peanuts and 0.5 µg/kg for aflatoxin M1 in milk, whereas the US Food and Drug Administration (FDA) has placed the limit at 20 ppb (FAO, 2004). Peanut and corn are the major contaminated products in almost all countries, especially exported raw peanut, which has become an issue of contention across countries (Galvez, *et al*., 2002). Aflatoxin was present in 44 % of all samples tested in South Asia. Furthermore, 87 % of samples contained aflatoxins, which for the most part occurred in finished feed samples (Biomin, 2019).

Ochratoxin is a mycotoxin that comes in three secondary metabolite forms, A, B, and C. All are produced by *Penicillium* and *Aspergillus* species (Bayman and Baker, 2006). *Aspergillus ochraceus* is found as a contaminant of a wide range of commodities including beverages such as beer and wine. *Aspergillus carbonarius* is the main species found on vine fruit, which releases its toxin during the juice making process (Mateo *et al*., 2007). OTA has been labelled as a carcinogen and a nephrotoxin, and has been linked to tumors in the

human urinary tract (Mateo *et al*., 2007). In 2011, the highest pre valence of OTA contamination in foods and feeds occurred in South Asia with a positive rate of 49 %, which is twice more than that found in North Asia (25 %) and Southeast Asia (28 %) (Biomin, 2011). Therefore, monitoring of the contamination status should be continued especially when the climate changes continuously.

Fusarium toxins are produced by over 50 species of *Fusarium* and have a history of infecting the grain of developing cereals such as wheat and maize (Cornely, 2008). They include a range of mycotoxins, such as: the fumonisins, which affect the nervous systems of horses and may cause cancer in rodents; the trichothecenes, which are most strongly associated with chronic and fatal toxic effects in animals and humans; and zearalenone, which is not correlated to any fatal toxic effects in animals or humans (Desjardins and Proctor, 2007). Fumonisins proved to be the most prevalent mycotoxins globally among the major agriculturally relevant mycotoxins, 96 % of corn samples in Asia tested positive for fumonisins with maximum concentrations of 47,485 ppb. FUM and DON are prevalent, particularly in corn. 96 % of all corn samples were contaminated with these two mycotoxins. The average contamination of FUM was at 3438 ppb, while DON levels were at 540 ppb on average. In Asia, the prevalence of mycotoxins is different from that in other geographical regions according to the percentage of positive samples. In Asia, the positive rate of fumonisins was 52 %, with an average level of 936 mg/kg. Among Asian regions, South Asia has the highest positive rate, which was 56 % (Biomin, 2019).

Zearalenone, previously named F2 toxin, is an estrogenic mycotoxin synthesized by *Fusarium* fungi with contamination occurring mainly in maize, wheat, and barley fields (Srianujata, 2011). Estrogenic syndrome is the major toxic effect of zearalenone. Hyperestrogen, vulvovaginitis, and estrogenic responses from zearalenone are observed in estrogenic target cells (Pillay *et al.*, 2002). In Asia, North Asia showed the highest contamination (63 %), Southeast Asia was second (37 %), and South Asia had the lowest rate (4 %) (Biomin, 2011). However, the average amount of zearalenone contamination in Asia was 129 mg/kg, which was still within the range of the maximum limits regulated in Asian countries.

Deoxynivalenol (DON) is a trichothecene mycotoxin produced by several plant pathogenic fungi, especially *F. graminearum* and *F. culmorum* (Rotter *et al*., 1996). DON is commonly found in wheat, maize, rye, rice, oat, and barley that are infected with *Fusarium* head blight (Rotter *et al*., 1996). DON is also known as “vomitoxin,” and its presence in foods can cause clinical or subclinical manifestations in humans and animals. The toxicity of DON mainly

affects the immune system and the gastrointestinal tract. Maximum limits for DON are commonly established for products such as unprocessed cereals and cereal products (*i.e.*, pasta and bread). For the EU, the maximum limits of DON are set at 500 ppb and 750 ppb for cereal products as consumed and other cereal products at retail storage, and flour used as raw material in food products, respectively (FAO, 2004).

STRATEGIES TO MITIGATE MYCOTOXIN CONTAMINATION

Fungi can invade, colonize, and produce mycotoxins during either preharvest or postharvest stages (Cheli *et al*., 2013). Therefore, to properly manage mycotoxin contamination in crops, the primary strategy is the prevention, by reducing fungi proliferation in field and during storage (Choudhary and Kumari, 2010). Commonly and usually, mycotoxinogenic fungi are divided into two groups: preharvest (mainly *Fusarium* species) and postharvest (mainly *Aspergillius* and *Penicillium* species) fungi. During storage, fungi and insects may cause further deterioration.

There are several possibilities for mitigating mycoto in contamination. Preharvest events are predominantly dictated by environmental factors and good agronomic/cultural practices. Conditions, such as excessive moisture, temperature extremes, humidity, drought conditions, insect damage, crop systems, and some agronomic practices, can cause stress and predispose plants in the field to mould and determine the severity of mycotoxin contamination. *Fusarium* sp. are generally associated with a cool and excessively wet growing season (Munkvold, 2014). Storage and processing are the major areas where contamination can be managed and mitigated at postharvest level, keeping in mind that postharvest contamination is also the result of preharvest presence of fungal contamination. The main strategies that need to be considered and implemented to mitigate mycotoxin accumulation pre and postharvest are summarized in Table 1.

Table 1. Emerging strategies to reduce mycotoxigenic fungi and mycotoxin contamination in Crops

Crop Stage	**Strategies**
Pre-harvest	• Resistant Crops: Breeding and Transgenic Crops • Agronomic Practices: o Good Agricultural Practices o Assess and care during Critical Control Points o Crop Rotation, Tillage o Crop planting should be timed to avoid high tem perature and drought stress during the period of seed development and maturation • Physiological stage of plant: making schedule for suitable harvest time • Chemical and biological control
Harvest	• Harvest at lower moisture content / Aw • Reduce mechanical damage to the seeds
Post-harvest	• Humidity and temperature during storage • Physical decontamination • Chemical Preservation and Biocontrol • Additives for gastrointestinal preservations • Processing (HACCP approach) • Physical decontamination: Sorting, dehulling, debranning, milling, irradiation, heating, or combined approaches • Inorganic or organic mycotoxin binders (Reduced food mycotoxin bioavailability) • Chemical decontamination: Conversion of mycotoxins via chemical reactions • Microbial based methods:Microbial transformation, biodegradation

CONCLUSION

The risk of contamination by mycotoxins is an important food safety concern for grains and other field crops. Mycotoxins are toxic byproducts of mold infestations affecting as much as one-quarter of global food and feed crop output. To protect consumers from these health risks, many countries have adopted regulations to limit exposure to mycotoxins. As with many food safety regulations, domestic and trade regimes governing mycotoxins often take the form of product, rather than process, standards. Recent investigations on the occurrence of mycotoxins in human foodstuffs have evidenced the seriousness of mycotoxins problem among Asian countries nowadays. Collaborations and cooperative research efforts among scientists and laboratories in Asian countries should be encouraged to assess the extent of human exposure to mycotoxins in this region.

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KEYNOTE ADDRESS

Climate Resilient Pest Management Innovations for Dryland Agriculture with Reference to Bio-Control

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I am greatly delighted to receive the invitation to attend the Fifth International Conference on Dry Zone Agriculture [ICDA-2019], being organized at the Faculty of Agriculture, University of Jaffna, Sri Lanka, and to share some thoughts on the future of pest management in dryland farming systems in the form of a Keynote Address entitled "Climate Resilient Pest Management Innovations for Dryland Agriculture with Reference to Bio Control". I extend my heart-felt gratitude to the Organizers for having given me the opportunity to address in this very important scientific event.

Dryland Agriculture refers to cultivation of crops entirely under natural rainfall without irrigation. It is a form of subsistence farming in the regions where deficit of the soil moisture retards the growth of certain water consuming crops like paddy, sugarcane, bananas *etc*. Dryland areas are characterized by peculiar environment with erratic rainfall and no assured irrigation facilities. Dryland areas receive scanty rainfall between 500 and 1200 mm. Globally, more than 2000 million people are inhabited in drylands, which account about 40 % of the world's population. More than 75 % of the peasants involved in dry farming are small and marginal farmers, many subsisting on less than US$1 per day. Regionally, Asia has the largest share of population living in drylands, with more than 1400 million people or 42 % of the region's population. Africa has nearly the same proportion (41 %) of people living in drylands although the total number is smaller with 270 million. South America has 30 % of its population living in drylands or about 87 million people. In India, dry land region is the largest, covering with 53 % of the country's geographical area. Nearly 50 % of the total rural workforce and 60 % of livestock in the country are

concentrated in the dryland areas. Currently, almost 60 % of the net sown area exists in rainfed contributing about 40 % of the total production and therefore, dryland areas plays an important role in providing livelihood to a large segment of population.

DISTRIBUTION OF DRYLANDS

Globally, drylands span about 40 % of the land area and nearly 60 % of the areas are occupied in developing countries . Most of the drylands of the world are found in Africa (66 %) followed by Asia (40 %), Europe (24 %) and Latin America (15 %). India has about 108 million hectares of rainfed area which constitutes nearly 75 % of the total 143 million hectares of arable land. In such areas crop production becomes relatively difficult as it mainly depends upon intensity and frequency of rainfall. In India, major dry farming crops are millets such as *jwar, bajra, ragi,* oilseeds like mustard, rapeseed and pulse crops like pigeon pea, gram and lentil. Almost 80 % of maize and *Jwar,* 90 % of *Bajra* and approximately 95 % of pulses and 75 % of oilseeds are obtained from dryland agriculture. In addition to these, 70 % of cotton is produced through dryland agriculture. Dryland areas also contribute significantly to wheat and rice production, which account 33 % of wheat and 66 % of rice are still under rainfed. Dryland agriculture is important for the economy as most of the coarse grain crops, pulses, oilseeds, and raw cotton are grown on these lands. In addition, dryland areas largely favour the development of several high value horticultural crops including many fruit and nut crops like mango, citrus, guava, aonla, pomegranate, ber, peach and cashewnut. In more than 30 tropical countries, where drylands endowed with red-laterite soils, cashewnut (*Anacardium occidentale* L.) are being cultivated in an area of 3.54 million ha producing 2.30 million tonnes of raw nuts with an estimated value of US$ 1.5-2 billion annually. On a conservative basis, dryland produces 44 % of food requirements, thus has and will continue to play a critical role in food security.

MAJOR AREAS OF CONCERN IN DRYLAND AGRICULTURE

Drylands are characterized by low and uncertain rainfall therefore, crop failure is common feature. In drylands, precipitation is counterbalanced by evaporation from the soil surfaces and transpiration by plants. Other constraints and challenges faced by farmers in the drylands include: extreme weather variability, frequent drought spells, with poor soil nutrient profiles, nutrient losses due to high rates of soil erosion, leaching, runoff, nutrient mining, lack of nutrient management, deforestation and loss of germplasm diversity and increased incidence of pests and diseases resulting in unsustainable crop yields, sometimes compete crop failure. The United Nations estimated that the world population would be 9.7 billion by 2050. Prospects for bringing additional land areas for increased agricultural production are very limited. So, contribution

of enhanced crop productivity through dryland farming is essential to feed the future population. Therefore, improvement of farming technology as well as from the expansion of crop cultivation in drylands is a key to the development of agriculture in rural areas, where farmers are resource poor.

CLIMATE CHANGE AND PEST PRESSURE

The long term study of weather clearly states that there are changes in weather parameters so called 'climate change', which inflicts adverse impact of biotic stresses in agro-ecosystem further. In the changing climatic conditions, there are great shift in pest dynamics in dry-land ecosystem, where cultivated crop are more vulnerable to biotic stress. Under dryland situations, certain specific insect pests such as thrips, mealy bug, scales and mite pests; plant diseases like wilt and root-rot aggravate under hot summer season. In contrast, pests such as aphids, leaf-hoppers and plant-hoppers; diseases such as cereals blast, mildews and fruit rots break-out under warm humid weather periods. Certain univoltine pests like coleopteran borers (red-palm weevil, rhinoceros beetles, wood borers) occurs round the year due to their long life cycle. Therefore, pest management action should be planned by understanding the life-span of pest/natural enemies and prevailing environmental conditions. In this context, Ecological Pest Management (EPM) contributes to climate change adaptation by providing a healthy and balanced ecosystem in which the vulnerability of plants to pests and diseases is decreased. Understanding mechanism of defense system in plants and understanding what makes a crop susceptible to pest attack is critical to devising management strategies that reduce crop losses, pesticide use and associated costs.

PEST ASSOCIATED LOSSES IN DRYLANDS

In general, the profitability of agriculture depends on productivity of crops at low production cost. More than 100,000 species of insects, mites, vertebrates, nematodes, plant pathogens and weed plants inhabit any given farm across the growing season. Only several dozen create potential problems. Fewer than a dozen pests will feed on or crowd out crops. Many pests have impressive abilities to reproduce often and disperse widely. In dry-land agriculture, the severity of biotic stresses continues to limit productivity by competition and destruction, which increase cost of production of food crops, especially when crop cultivation is expanded in large-scale or with heavy inputs applications. In general, crops grown in drylands are lost to the tune of 25 % due to insects, due to diseases including that of nematodes up to 20 %, vertebrate pests including rodents about 6-8 percent. However, localized crop losses due to sudden outbreaks of some polyphagous pests and crop diseases would become enormous, even resulting in complete crop failure. From 1965 to 1990, as conventional pest control intensified, estimated crop losses from

insects, diseases and weeds increased from about 35 % to 42 % worldwide. That suggests conventional approaches are not effective in many situations. Alternate measures are absolutely necessary for reducing pest pressure.

PRACTICES FOR REDUCING PEST PRESSURES IN DRYLANDS

In drylands farming, reducing pest problems relies on many 'little hammers', each contributing to one or more of the following general strategies: (1) producing healthy crops, (2) increasing stress on pests, (3) enhancing native biocontrol organisms. All these vital farming practices provide growth of healthy plants, which in turn can better compete with pests or protect against them, are keys to minimizing pest problems on the farm.

Producing Healthy Crops: Generally, vigorous crops tolerate even extensive damage of pests and diseases, and compete better with weeds. Maintaining plant health management by reducing environmental stresses via better soil and crop management helps plants better compete with or resist pests. Therefore, the link between healthy soils and healthy plants remains fundamental to ecologically based pest management. Maintaining soil health with adequate soil moisture, liberal aeration in soil, balance of soil nutrients and soil organic matter and enhancing diverse community of soil organisms all contribute to promote plant health, and discourage the pestiferous organisms. For instance, antagonistic microorganisms that colonize plant roots can prevent disease infection caused by *Pythium* and *Rhizoctonia* in many crop plants. Inoculating transplants with beneficial mycorrhizal fungi has protected crop plants from root rot fungi such as *Cylindrocarpon* and *Pythium*. Composting organic-waste residues before applying them to soils may help fight crop diseases, and to produce high-value food crops commodities such as cereals, vegetables and fruits.

Increasing Stress on Pests: Creating multiple stresses on pests may discourage their dispersal or connection with crops. Disrupt the pest populations by destabilizing habitat with the following habitat manipulations *viz*., (a) Selection of pest-resistant, local, native varieties and well adapted cultivars; (b) Use of legume-based crop rotations to increase soil nitrate availability thereby improving soil fertility and favourable conditions for robust plants that better face pests and diseases; (c) Use of cover crops, such as green manure to reduce weed infestation, disease and pest attacks; (d) Integration of intercropping, crop rotation and avoiding monoculture of crops; (e) Growing multiple crops of annual, biennial, and perennial nature with agro-forestry systems; (f) Manipulation of crop spacing and pruning to create conditions unfavourable to the pests, and suppress weeds, especially when adopting narrower/ closer plant to plant and row to row spacing; (g) Growing

a non-host crop in a rotation sequence are very important bearings to create stress on pest organisms.

Enhancing Beneficial Organisms: Beneficial predatory and parasitic organisms generally do not flourish in fields with only one plant species. They need overwintering sites and different types of microenvironments such as shady, moist places, where they can find protection from their own natural enemies. Besides, the beneficial arthropods often need additional sources of food. Parasitic wasps and predacious hoverflies, for example, depend on a daily supply of honeydew, nectar and pollen for energy and reproduction.

Alternative food sources are critical to the development of slow-reproducing predators. To improve habitat for beneficial organisms, consider sowing cover crops between rows of cash crops; maintaining beneficial insectary plantings at field edges, providing permanent refuge strips for soil dwelling generalist predators; through supplying root disease-suppressing microbes with life-sustaining organic matter by means of cover crops, animal manures and composts.

PEST MANAGEMENT APPROACHES

Among the various methods of pest control, chemical method still enjoys first choice because of its quick, certain and efficacious action. However, chemical method of crop protection has become risky and hazardous and also contains pesticide residue. Ecological based integrated pest management (IPM) approaches are viable for long-term pest suppression. To control any individual pest organism, we need to understand how it relates to the ecosystem in which it operates. Many pests have impressive abilities to reproduce often and disperse widely. Large-scale intensive break-out of pests and diseases has been reduced due to combination of modern chemistry of pesticides that have environmental-friendly formulation chemistry. Such pesticides can be therapeutic and could enable restoration of natural agro-ecological food webs. But, in the excitement to enhance the production, and commercial agriculture tended to ignore the natural balance, and the sudden spurt in pestilence became the order of the day.

Integrated Pest Management: Many countries adopted IPM as the policy drive to manage the various crop pests. The IPM approach use multiple tactics such as cultural, physical, mechanical, biological and chemical methods in a compatible manner to maintain pest populations at levels below those causing economic injury while providing protection against hazards to humans, animals, plants and the environment. Currently, this approach is also termed as 'Ecological Pest Management (EPM)' which increases the strengths of

natural systems to reinforce the natural processes of pest regulation and improve agricultural production. IPM/EPM emphasizes the growth of a healthy crop with the least possible disruption of agro-ecosystems, thereby encouraging natural biological pest control mechanisms. Chemical control should be adopted as last resort only where and when these natural methods fail to keep pests below damaging levels. "*Thus, IPM is a dynamic and constantly evolving system in which all suitable control tactics and available surveillance and forecasting information are synthesized into a holistic management programme delivered to farmers at intervals as part of sustainable crop management technique".*

Options for Chemical Control: Prophylactic use of pesticides is a common feature of any wide-area crop production systems. Despite, to control pests, disrupt their life cycles or deny their access to crops, farmers have an assortment of conventional chemical pesticides and biorational materials at their disposal. Conventional chemicals include synthetic, broad-spectrum pesticides that often leave in their wake unwanted side effects, harming other non-target species or polluting the environment. Biorationals are more specifically toxic to or disruptive of target pests. naturally derived or synthesized, they include growth regulators, microbial toxins, anti-feeding/ repelling agents, pest-smothering oils, and disruption pheromones that confuse insects and reduce their reproductive success. For effective chemical control, the following aspects have important bearings in the context of ecological based IPM technology.

- Avoid tank-mixing spray strategies of blending two or more pesticides
- Avoid repeated sprays of same pesticide which build resistance in insects
- Alternate the sprays with different group of pesticides
- Avoid using sub-lethal dose of pesticide, which end-up in control failure
- Avoid frequent use of synthetic pyrethroids, which induce resurgence of sucking pests
- Use proper spray timing, volume and equipments for effective control of pests
- Restrict pesticidal sprays during flowering phase to protect pollinators
- Spray pesticides preferably in the evening hours for maximizing efficacy
- Apply insecticides only after proper justification of pest surveillance

Biological Pest Control: Biological control is an important component of pest management in any crop production system. The biocontrol agents comprising of predators, parasites and disease causing organisms are categorized into two broad types *viz.,* (1) Macrobials (predators and parasitoids) and (2) Microbials (viruses, bacteria, fungi and endophytes). They are present in the crop itself and also in neighbouring fields and crops. These feed on/parasitize/infect the preferred pests during their life time, and provide

a large measure of pest control. The role of macrobial and microbial agents in long-term suppression of harmful pests in dryland agriculture is out-lined here.

Macrobials: Macrobials are characterized by their larger size than the host insects. the giant predators (ladybirds, spiders, lacewings, weaver ants, birds *etc*) are the most commonly observed natural enemies, while the tiny parasitoids (parasitic wasps, flies *etc*) often have the greater control effect- these are often referred to as 'farmer's friends'. Among the predators, many species of spiders are efficient predators of crop pests. Predatory spiders actively hunt or spin webs to trap small herbivores (insects/mites), and use their venom to paralyze or kill their prey constantly. Many species of spiders live in fields and tends to hide under debris/crop residues as permanent residents, forming a more stable group of the predator community than any other predators not only because of their broader diet breadth, but also their ability to subsist for long periods of time without food. Managing field boundaries and in-field habitats with border crops/intercrops is useful to attract beneficial insects, and trap or confuse insect pests.

Microbials: Microbials are microscopic in size, and they include insect pathogenic viruses, bacteria, fungi and endophytes, all are capable of cause diseases among insect/mite pests by spreading contagious diseases. These entomopathogenic organisms can be commercially formulated for application as microbial pesticides, such as nucleopolyhedrosis virus (NPV) and *Bacillus thuringiensis* Berliner (Bt); mycoinsecticides based on *Beauveria bassiana* (Bals.) Vuil., and *Metarhizium anisopliae* (Metsch) Sorokin; and disease antagonistic organism *Trichoderma viride* Persoon. Proper habitat manipulation by soil health management, creating stress to pest population and augmentation of specific microorganism in fields are essential for potential actions of biocontrol pathogens.

Endophytic Microorganisms: Recent researches confirmed that some specific strains of bacterial and fungal entomopathogens functioning as endophytes, which are well known to contribute plant fitness benefits, enabling adaptation of the plant host to biotic and abiotic stresses. Endophytes establish symptomless colonization within healthy plant tissues and provide long-term systemic resistance against plant pests and diseases. Unlike many plant pathogens, endophytes do not produce haustoria and so do not directly cause cell damage. Instead, endophytes produce hormones useful to support plant health. A diverse group of endophytic organisms, which largely contribute via induced systemic resistance, have been isolated from numerous species of crop plants.

• Techniques of mass production, product development and methods of field application have been standardized for endophytic fungi such as *B. bassiana*, *M. anisopliae* and *T. viride* for wider scale adoption. Endophytes have been formulated as granules, wettable powder and oil-in-water emulsion forms, which can be applied as that of conventional pesticides through seed treatment, seedling root-dip, soil drenching, foliar application and fertigation modes.

• Successful introduction and establishment of endophytes in crop plants grown drylands environment requires maintenance of optimum soil moisture and desired organic matter content for long-term pest suppression.

• Once established sucessfully, endophytic colonization is expected to alter nutrient profile favourable to crop plants, which induce the production of beneficial secondary metabolites, which could protect plants from herbivores and pathogenic diseases. Changes in nutrients/chemical composition in plant system tend to cause antibiosis, feeding/oviposition deterrent effects against herbivores, and antagonistic action against plant pathogens.

• Since majority of fungal endophytes are soil-borne, these can be established in fields with repeated introduction that aids in in situ self-replication and auto-dissemination in fields under favourable environment, especially with creation of humid weather.

CONCLUSION AND FUTURE THRUST

In conclusion, it can be said that dryland areas are potential contributors for production of diversified crops such as cereals, coarse grain crops, pulses, oilseeds, and cotton. Moreover, drylands also contribute significantly to the production of vegetables, fruits and high value nut crops. In dryland areas, the productivity of food crops is largely hampered due to severity of pests and diseases. In principle, pest management involves preventive and curative intervention measures in any crop production system. Preventive methods comprises cultural practices like summer and pre monsoon ploughing, preserving soil health, use of resistant/tolerant varieties, suitable crop rotation, incorporation of intercrops, judicious water and nutrient management, while curative intervention methods focuses on integration of mechanical, biological and chemical control, collectively called IPM.

In dryland farming, IPM substantially contributes to climate change adaptation by maintaining and providing a balanced ecosystem in which the vulnerability of plants to pests and diseases is decreased. Understanding mechanism of defense system in plants and understanding what makes a crop susceptible to pest attack is critical to reduce crop losses, pesticide use and associated costs under dryland agriculture.

• Encouraging beneficial fauna such as crop pollinators, and biocontrol agents such as macrobials (parasitoids, predators), and microbials (insect pathogenic viruses, bacteria, fungi) are crucial biological practices in IPM

• Biological control can also be enhanced by the mass rearing and release of beneficial insects such as *Trichogramma,* and *Chrysoperla.* Conservation and augmentation of all these resident biocontrol agents are to be given prime importance in the drylands pest management system

• Research aimed at developing innovative biological control methods should be promoted, in line with introduction and establishment of endophytic microorganisms as a component of induced systemic resistance as long-term bio-control mechanism in drylands ecosystem.

• Research efforts to design nanopesticide formulations suited to drylands cropping system should be developed

• Finally, application of the Internet of Things (IoT) should be developed as diagnostic tool for identifying nature of pest damage and to provide control recommendations to improve overall crop productivity in drylands

KEYNOTE ADDRESS

The Water-Energy-Food Nexus: Challenges and Tools

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Water, energy and food are essential for all. They sustain societies, economies and ecosystems. Demand for these has increased in the past and that trend will continue over the decades to come. Among others, population growth, urbanization, economic development, cultural and technological changes, international trade, and climate change are considered as the main reasons for this increase.

Agriculture (including irrigation, livestock and aquaculture) is the largest water consumer, accounting for 69 % of annual global freshwater withdrawals while industry (including power generation) accounts for 19 % and households for 12 % (FAO, AQUASTAT). The food production and supply chain consumes about 30 % of total global energy production (FAO, 2011). Water for energy currently amounts to about 8 % of global water withdrawals while energy is often required for supplying water for diverse purposes. Likewise, water, energy and food sectors are interlinked in many ways as well as these sectors are highly inter-dependable.

Added to that, about 60 % more food will need to be produced to feed the world population in 2050. Global energy consumption is projected to grow by nearly 50 % by 2035. Total global water withdrawals for irrigation are projected to increase by about 10 % by 2050. Overall, global water demand, in terms of water withdrawals, is projected to increase by 55 % by 2050 (OECD, 2012). These increases will result in raising competition for resources among water, energy and agriculture sectors with unpredictable impacts on livelihoods and environment. Further, climate change adds uncertainty to the complex interrelations among the water, energy and food sectors and increases the

need for sustainable resource use (Holtermann and Nandalal, 2015).

Thus, the complex linkages among water, energy, and food systems require a suitably integrated approach to ensure water and food security, and sustainable agriculture and energy production worldwide at present as well as in future. The water-energy-food nexus is a novel approach that aims to identify tradeoffs and synergies of water, energy and food systems for addressing complex resource and development challenges (Albrecht *et al.*, 2018). The nexus approach emerged as a useful concept to describe and address complex and interrelated nature of the global resource systems on which we depend to achieve different social, economic and environmental goals. It presents a conceptual approach to better understand and systematically analyze interactions between natural environment and human activities, and to work towards a more coordinated management and use of natural resources across water, energy and food sectors.

Undoubtedly, achieving water, energy and food security worldwide is very vital. However, managing supply-side of these sectors to achieve this security has become impossible. Since resources in all the three sectors are limited, efforts are essential to be made towards increased resource use efficiency, demand management and more sustainable consumption patterns to achieve water, energy and food security. Apparently, an integrated view across the nexus provides more comprehensive information on relative resource scarcity and productivity, and on the potential for sustainable intensification of services. Further, concepts such as Integrated Water Resources Management need to evolve towards partnerships with water-using sectors whose policies and strategies are governed by many factors outside the water sector. This new water-energy-food nexus approach identifies mutually beneficial responses and provides an informed and transparent framework for determining trade-offs and synergies that meet demand without compromising sustainability.

Simple and comprehensive tools are required to assist decision makers in dealing with the complexity of interrelations in the water-energy-food nexus by helping them to assess trade-offs and explore synergies. These tools should define and quantify the interconnectivity in the water-energy-food nexus and provide a solid basis for integrative strategies and holistic management of water, energy and food resources. (a) Climate, Land-use, Energy, Water (CLEW) framework, (b) Water, Energy, Food Nexus Tool 2.0, (c) MARKAL, (d) Water Evaluation and Planning system (WEAP), (e) MuSIASEM flow-Fund model, are a few such tools available for water-energy-food nexus based decision making (Kaddoura and El Khatib, 2017).

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Abstracts

Agronomy, Crop Production, Forestry and Natural Resources

Enhancing Storability of Ridge Gourd Seeds Under Ambient Conditions by Silica Gel

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The storage of vegetable seeds after harvest until next planting time assumes prime importance for successful breeding and seed production programmes, since the viability and vigour in storage is regulated by many physio-chemical factors. Therefore, experiments were carried out to study the possibility of enhancing storability of ridge gourd seeds using silica gel under ambient conditions at the Department of Vegetable Science, Horticultural College and Research Institute, Coimbatore during 2017-2018 using seeds of ridge gourd CO1. The experimental design was Factorial Randomized Complete Block Design with four replications. Factor 1 included 3 levels of moisture content *viz.,* 9 % (shade dried fresh seeds), 6 % and 4 % (dried using Silica gel). Factor 2 included four different packing materials *viz.,* Aluminium foil (polylined), polyethylene cover (500 gauge), polyethylene cover (700 gauge) and cloth bag and stored for 15 months under ambient temperature. At three months intervals (0, 3, 6, 9, 12 and 15 months) the seeds from different packing materials were sown on paper towels and observations on seed growth parameters *viz.,* Germination percentage, Vigour index I and Vigour index II were recorded. The results showed that during "0" storage period the seeds with 6 % moisture content packed in polythene cover of 500 gauge thickness recorded a higher germination percentage (74 %), vigour Index I and II (3142.2 and 71 respectively). During 3 months, the Vigour Index II (49) was higher in seeds with 6 % moisture content packed in polythene cover of 500-gauge thickness. During 6 months, seeds with 4 % moisture content packed in polythene cover of 500-gauge thickness recorded higher germination percentage (57 %) and Vigour Index I (2111.85). During 9 months, the seeds with 4 % moisture content packed in Aluminium foil registered higher germination percentage (88 %) and Vigour Index II (91.68). It can be inferred that the seeds packed in aluminum foil (polylined) expressed the highest germination percentage (88 %) and vigour index II (91.68) up to 9 months. Desiccated seeds stored in moisture impervious containers produced seedlings that are more vigourous. Thus, adoption of appropriate moisture level and packing materials would significantly increase the storability of ridge gourd seeds under ambient conditions.

Keywords: Germination percentage, Ridge gourd storability, Vigour index

Morphological Features of Different Rubber Clones (*Hevea brasiliensis* Mull. Arg) in Varying Climatic Conditions in Two Selected Regions of Sri Lanka

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Modern clones of rubber perform well but show variability among them for yield, growth, tolerance to disease and adaptability to climate. Agronomical practices such as planting distances and tapping system that should be applied depend on the clone. Inability to maintain pure stands of clones in cultivation effects seriously for tapping panel dryness, quality and quantity of yield and for variation in reaching the tappable girth. Therefore recognizing a clone accurately is upmost importance for achieving potential yield of a given clone following recommended procedure. Morphological variability of modern clones cannot be explained broadly due to limited genetic variability in the present clones. Objective of this study was to group or separate clones using their prominent morphological features. Plants were raised in poly bags using young budding techniques in both wet (Egaloya-WL1a) and dry (Ampara-DL2a) regions of Sri Lanka in year 2014. According to a Randomize Complete Block Design (RCBD), 320 plants of 8 clones *viz*. PB 86, PB 260, RRIC 100, RRIC 102, RRIC 121, RRISL 203, RRISL 217 and RRISL 2001 were established as bud wood nurseries, using 40 plants per each clone in two areas. In this study, morphological attributes *viz*. length of second internode, number of leaf whorls, mean leaf length, mean maximum leaf width and total leaf area of a whorl were measured in 2015. Twenty nine of other morphological features such as Shape of axillary bud and leaf scar, Shape of leaf storey and Leaflet color, *etc.* were also recorded in 2017 (after three years of bud grafting). According to the result RRIC 102 recorded the highest internode length as 19.09 and 10.47 cm in wet and dry zone separately. Nevertheless average maximum leaf sizes of second and third leaf whorl in two regions which are 109.88, 125.50, 85.29 and 101.60 cm^2 respectively, shown by this clone. Eight clones in both zones basically have been clustered on other 29 features. The dendrograms obtained for the two regions show that the eight clones have grouped into two main groups with the three sub-clusters. It further shows that the clones have behaved similarly in each region except for PB 260, RRIC 100 and RRIC 121.

Keywords: Climatic variations, Growth, *Hevea* clones, Morphology, Sri Lanka

Performance of Selected Leafy Vegetables Under Different Shade Levels

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Cultivation of leafy vegetables under shade houses could be used to improve the quantity and quality of the yield. Performance of leafy vegetables under different shade levels was studied from March to May 2016 at Integrated Farm and Training Centre, Kanakarayan Kulam, Vavuniya, Sri Lanka. The experiment was arranged in a Randomized Complete Design with three replicates. Four types of leafy vegetables; *Centella asiatica* (*Vallari*), *Amaranthus tricolor* (*Keerai*), *Ipomoea aquatic* (Water spinach) and *Lactuca sativa* (Lettuce) were cultivated under 0, 50 and 75 % shade levels with three replicates. Growth, yield parameters and sensory attributes were evaluated. Growth and yield data were analyzed by ANOVA procedure in SAS and *Kruskal-Wallis* test was performed for sensory data. Result revealed that the 50 % shade level significantly ($P < 0.05$) increased the growth and yield of *C. asiatica*, *A. tricolor,* and *L. sativa,* while 0 % shade level enhanced the growth and yield of *I. aquatic*. Similarly, sensory characters of leaf colour, leaf size and overall appearances of the crop were evaluated showed the same results. Therefore, it can be concluded that the growth and yield of leafy vegetables were greatly influenced by a 50 % shade level except *I. aquatic.* The present study suggests that the adoption of 50 % of shade house technique for leafy vegetable cultivation could improve the overall growth and total yield to the farmers in Vavuniya district.

Keywords: Growth, Leafy vegetables, Sensory evaluation, Shade level, Yield

Effect of Spacing and Application of Foliar Nutrients on Growth and Yield of Black Pepper (*Piper nigrum*)

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An experiment was conducted at Horticultural Research Station, Pechiparai, Tamil Nadu, India during 2014-17. The objective of the study was to find out the effect of different spacing and foliar nutrients on the growth and yield of black pepper. The variety Panniyur-1 (Bush type) was selected for the study. The soil of the experimental area is red laterite and this experiment was laid out in Factorial Randomized Block Design and is replicated thrice. The details of the treatments are spacing (S) treatments S_1- 2.0 x 2.0 m , S_2- 1.5 x 1.5 m, S_3- 1.0 x 1.0 m and the foliar nutrient (F) treatments are F_1-Humic acid @ 0.2 per cent, F_2 – Panchagavya @ 3.0 per cent, F_3-NPK 19:19:19 spray @ 0.2 %, F_4-GA3 spray @ 20 ppm and F_5 – Control (water spray). Soil application of 1.0:0.5:2.0 g of NPK per plant at bimonthly intervals was applied uniformly to all the plants as per the recommended package of practices of Tamil Nadu. The foliar nutrients as per the treatment specification were imposed for achieving a rapid response and were given in fortnightly intervals commencing from third month after planting. Observations were recorded on the height of the bushes at the time of harvest, number of spikes/bush, spike length and number of berries/spike. The green berry yield was also recorded. Among the different treatments S_1F_3 (spacing of 2.0 x 2.0 m and NPK 19:19:19 spray @ 0.2 %) recorded the highest number of spikes per plant (143.10), Spike length (16.24 cm) and the highest green berry yield of 1.100 kg/bush and it was significantly superior over other treatments.

Keywords: Bush black pepper, Foliar application, India, Panniyur– 1, Spacing

Strategies for Extending the Longevity of Cut Lotus (*Nelumbo nucifera*) Flowers

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Lotus (*Nelumbo nucifera)* is an aquatic plant and the flowers are used for religious purposes and floral decorations. Improper post-harvest handling practices, high rate of respiration and transpiration leads to short vase life of lotus flowers about 1-2 days. With a view to improve postharvest life of cut lotus flowers, a study was conducted to develop a package of practices to maintain flower quality. In the first experiment three maturity stages as indicated by flower bud diameter (1-2 cm, 2-3 cm and partially bloomed) were plucked at different day times (6 am, 7 am and 5 pm) and vase life in deionized water was evaluated. Based on the results, best matured flowers were plucked at suitable day time and were kept in three preservative vase solutions namely, 1. Citric acid (100 mg/L) + 2 % sugar + aluminium sulfate (200 mg/L), 2. Salicylic acid (100 mg/L) + 3 % sugar, 3. 6-BAP (15 mg/L) + 2 % sugar + citric acid (192 mg/L) and 4. Deionized water (control) in the second experiment. Flowers were kept either in ambient condition (30–35 °C) or at low temperature (22-25 °C). The experiment was carried out in two steps and experimental design was two-factor Factorial Complete Randomized Design (CRD) with five replicates. Flower quality (flower bud diameter, flower weight, total soluble solid), vase life and solution uptake were assessed. Flower bud diameter, flower weight and flower longevity were significantly ($P < 0.05$) different. Flowers with 2-3 cm diameter of flowerhead were harvested around 6 am and were one day longer than the control while maintaining flower quality. A vase solution of 6-BAP (15 mg/L) + 2 % sugar + citric acid (192 mg/L) combined with placing in low temperature extended the flower quality up to four days which was two days longer than the control.

Keywords: Flower quality, Lotus flowers, Preservative solutions, Vase life

Determination of Photosynthetic Biomass in Early Growth Stages of Agarwood, (*Aquilaria malaccensis*)

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Accumulation of photosynthetic biomass (PB) in the plants is an initial step in the expression of life respective to primary production, which releases oxygen and water vapor into the atmosphere and absorbs solar or other electromagnetic radiation. The main objectives of the study are to estimate the PB gain in the early growth phase of Agarwood and whether this is an exponential growth relationship with the age of the early growth phase. The study was carried out in selected homegardens of Batuwangala, Neluwa, Sri Lanka (Low country wet zone). The PB accumulation in leaves at early growth stages was recorded based on field data collected, through physical measurement and direct observation. Sampling was carried out through purposive sampling in four sites which represent the early growth phase at 1, 2, 3 and 4 years, altogether, 40 individuals were selected by grouping 10 individuates at each growth phase. Fresh weight was measured from the collected leaves and analyzed to derive PB curves. Total tree height, crown height and diameter of the stem was measured from selected individuals. MS excel (2016) was used for illustrate plot graphs for variables. PB of Agarwood was showed exponential growth after the age of 3 years with reference to the regression analysis the PB had a significant relationship with age. According to the PB results obtained for the Agarwood with the tree height, crown height, and tree diameter which also showed an increasing trend. In conclusion, the species Agarwood shows an increasing trend of PB with age up to 3 years and exponential growth thereafter.

Keywords: Crown height, Early growth stage, Photosynthetic biomass, Tree diameter, Tree height

Evaluation of Agronomic Performance and Consumer Preference of Selected Watermelon Cultivars in Northern Sri Lanka

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The watermelon (*Citrullus lanatus*) is a highly demand fruit in dry zone of Sri Lanka. Identifying a best suitable cultivar for dry zone is essential. The objectives of the study were, to identify the suitable cultivars in Northern Sri Lanka and to assess the consumer preference on different watermelon cultivars. A field trail was conducted at Sri Lanka School of Agriculture, Paranthan farm practice field between April to August in 2019 and all the students (20) of batch 2019/20 were selected for analyzing consumer preference. Four cultivars such as 'Sugarbaby', 'Thilini', 'Pilot-F_1' and 'Manulla-F_1' were selected. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicates. For growth performance, main vine length, number of vines, number of branches, number of leaves, leaf area per plant and for yield performance, days to flowering, sex ratio, number of fruits per plant and fruit weight were considered. Additionally, major pest and disease incidence and consumer preference were assessed based on the color, appearance, aroma, no of seeds and flavor of each cultivar by using "likert scale". The statistical analysis was done using Minitab statistical software (Version 18). Analysis of Variance (ANOVA) was declared significant at 5 % level. Turkey grouping was used to separate the mean and linear correlation. Results were concluded that, no any significant difference between varieties and growth performance while there was a significant difference ($P < 0.05$) in yield performance in terms of number of fruits per plant and fruit weight. Accordingly, mean number of fruits per plant from pilot–F_1, thilini, sugarbaby and manulla-F_1 were 7.75, 7.0, 4.25 and 2.5 respectively. With respect to mean fruit weight, pilot-F_1, thilini, sugarbaby and manulla-F_1 were 0.937, 1.28, 1.78 and 0.981 kg and respectively. In accordance with consumer preference, thilini was not preferred because of undesirable color, flavor, aroma, more number of seeds and inner and outer appearance. Sugarbaby was highly preferred than the Thilini and Manulla-F_1 and which was recorded least percentage of pest and disease incidences. Therefore, 'Sugarbaby' showed its potential. The Pilot- F_1 emerged the better performer though it contained some desirable traits for fruit fly attack. Hence, since it contains more desirable than undesirable agronomic traits, it should be improved for production especially in Northern Sri Lanka and seed companies should make efforts of availing its seeds to growers.

Keywords: Agronomic performance, Consumer preference, Northern, Sri Lanka, Watermelon

Use of Terminal Orthotropic Shoots for Production of Black Pepper (*Piper nigrum* L.) Planting Material in Sri Lanka

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Sri Lanka is a leading black pepper producer in the world. Lack of quality planting material is a major constraint in the country. Recently, the Department of Export Agriculture introduced the novel method of production of plants using terminal orthotropic shoots, which are the most vigorous shoot of pepper vine with terminal bud and few lateral shoots. Cuttings obtained from ground runners generally start to flower after three years from establishment, giving rise to fruits in lateral branches at a height of two to three feet from the base of the bush. However, the vines obtained using terminal orthotropic branches start flowering right from the base of the vine resulting in a large number of fruit bearing lateral branches. Plants propagated by terminal orthotropic branches produces flowers earlier compared to plants produced using other propagation materials. Terminal orthotropic shoots are free from *Phytophthora* infection due to no contact with soil compared to runners is an addition of benefit. This study was carried out with the objective of identifying the extent to which growers are aware on the new propagation technique, benefits, problems arising during adoption, and the role of extension services in dissemination of information regarding these planting materials. The study was conducted in the Matale district; the district has the highest land area of pepper in Sri Lanka. A 100 sample of black pepper growers and 25 pepper nursery owners were selected for the study and a pre-tested questionnaire was used for the data collection. A majority of growers were not aware of this novel method and farmers experienced both benefits and constraints at adoption. Almost all the pepper growers in Matale district use ground runners as the primary source of planting material in their cultivations, while a majority were not aware on the ability of using orthotropic terminal branches as planting material. The difficulty of finding large number of terminal shoots from pepper fields and higher price compare to the ground runners were the major problems for nursery owners. It was concluded that awareness on importance of this planting material through extension services and potential for decreasing the price of planting materials can be used as remedies to increase the use of plants produced from terminal orthotropic shoots.

Keywords: Black pepper, Terminal orthotropic shoots, Propagation

Soil Quality and Yield Performance of Dry Direct Seeded *Boro* Rice in Response to Organic Amendments

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Dry direct seeding is an alternative method that allows rice cultivation using 50-60 % less irrigation water input compared to the puddle transplanted conventional irrigation system. Information about the effect of organic amend ment on the yield performance of rice in this new system is scarce. The present study was conducted at farmer's field of Rajshahi district (24°75' N latitude, 90°50' E longitude, altitude 18 m) of Bangladesh to evaluate the effect of organic amendment on soil quality and yield performance of dry season (*boro*) rice. The organic amendments was done with Trichocompost (TC), Vermicompost (VC) and Mustard oil cake (MOC). Trichocompost and Vermicompost were applied 3 t ha^{-1} while Mustard oil cake was applied 0.5 t ha^{-1}. The treatments used for the experiment were T_0=Control (no organic matter applied), T_1=Trichocompost (TC) @ 3 t ha^{-1}, T_2=Vermicompost (VC) @ 3 t ha^{-1}, T_3=Mustard oil cake (MOC) @ 0.5 t ha^{-1}, T_4=Trichocompost @ 3 t ha^{-1}+ Mustard oil cake @ 0.5 t ha^{-1}, T_5=Vermicompost @ 3 t ha^{-1} + Mustard oil cake @ 0.5 t ha^{-1}. All the experimental plots received inorganic fertilizers at their recommended rates. The experiment was laid out in a Randomized Complete Block Design with three replications. Data on plant height, grain yield, yield attributes and soil parameters were collected and subjected to statistical analysis; using the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test with the help of a computer package programme Statistix10. The results revealed that the rice grain yield of BRRI dhan28 for trichocompost and vermicompost applied plots were 5.95 and 5.57 t ha^{-1} while that for the control plot was only 4.25 t ha^{-1}. The addition of mustard oilcake with trichocompost or vermicompost did not add any yield advantages over the compost application alone. The organic amendments did not have any significant influence on soil pH, organic matter content, bulk density, field capacity, phosphorus and potassium content. The present study concludes that yield of dry direct seeded *boro* rice can be improved by applying amendments with trichocompost or vermicompost @ 3 t ha^{-1}in addition to inorganic fertilizers at their recommended rates.

Keywords: Dry direct seeding, Dry season rice, Organic amendment, Water saving technology

Effect of Drip Fertigation on Growth, Yield and Quality of Ridge Gourd (*Luffa acutangula* L. Roxb)

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A field experiment was carried out at College Orchard, Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. To standardize drip fertigation for ridge gourd hybrid COH 1 (*Luffa acutangula* L. Roxb). The trials were conducted with a view to improve growth, yield and quality to compare the efficacy of water soluble and straight fertilizers for ridge gourd. A fertilizer dosage of 250:100:100 kg NPK ha^{-1} was adopted for ridge gourd hybrid (COH1). The treatment consisted of seven levels of fertilizers consisting of three levels in straight fertilizers (125, 100 and 75 % of 250:100:100 kg NPK ha^{-1}) and three levels in Water-Soluble Fertilizers (WSF) (125, 100 and 75 % of 250:100:100 kg NPK ha^{-}) and a control (100 % soil application of straight fertilizers) replicated thrice in Randomized Block Design. Water soluble fertilizers and straight fertilizers contain NPK only but WSF are in water soluble form which makes difference of nutrient availability to the plants. The irrigation water used was same for all the treatments with a pH 7.7 and EC of 2.2. From the study, it was found that fertigation treatments were significantly superior over the soil application of fertilizers (control). The fertigation treatment with 125 per cent WSF (T_5) recorded the highest values for growth and physiological characters *viz.*, vine length (9.65 m), stem girth (5.47 cm) and total chlorophyll content (2.59 mg/100 g). In case of yield parameters, the highest values were registered for fruit length (38.89 cm), fruit girth (19.65 cm), fruit weight (391.11 g), yield per vine (6.05 kg), number of harvests (14.10) and number of fruits/vine (17.84) in 125 per cent Recommended Dose of Fertilizers (RDF) (250:100:100 kg ha^{-1}) through WSF (T_5) followed by 100 per cent RDF through WSF. The quality parameters like calcium (15.54 mg/100 g), ascorbic acid (8.14 mg/100 g) and phosphorus (0.66 mg/100 g) content were found to be the highest with 125 per cent RDF through water soluble fertilizers. Therefore (T_5) 125 per cent RDF through WSF can be recommended for getting increased growth, yield and quality in ridge gourd hybrid COH1. The benefit cost ratio of the treatment T_5 is 1.65.

Keywords: Drip fertigation, Growth, Quality, Ridge gourd, Water soluble fertilizers, Yield

Effect of Nutrient Levels and Plant Growth Regulators on Growth and Yield of Pearl Millet Under Rainfed Condition

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A field experiment was carried out during *rabi* season 2016, to study the effect of nutrient levels and plant growth regulators on growth and yield of pearl millet. Ten treatments were imposed with three replications using RBD. The treatments *viz.,* 125, 100 and 75 % Recommended Dose of Fertilizer (RDF) alone, 125, 100 and 75 % RDF with Chlormequat Chloride @ 250 ppm at 20 and 40 DAS and 125, 100 and 75 % RDF with foliar application of NAA @ 40 ppm at 20 and 40 DAS were used as treatments. Without any chemical application was used as control. All the growth and physiological parameters were recorded accordingly. The significantly higher plant height, total number tillers, leaf area index, dry matter production, chlorophyll index, higher grain and stover yield were recorded with application of 125 % RDF + Foliar application of NAA @ 40 ppm at 20 and 40 DAS. Whereas application of 100 % RDF + foliar application of NAA @ 40 ppm at 20 and 40 DAS realized higher monetary returns (Indian Rs. 34,410/ha) having the benefit cost ratio of 2.0

Keywords: Chloromequat chloride, NAA, Nutrient levels, Pearl millet, Plant growth regulators, Yield

Evaluation of the Suitability of Different Rooting Media and Length of Cuttings on Growth and Yield Performance of Mint (*Mentha* spp.)

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Mint (*Mentha* spp.) is an aromatic perennial herb and it is popular in the world due to its specific aroma. Currently it is not cultivated commercially in Sri Lanka. An experiment was conducted to evaluate the suitability of different rooting media and length of cuttings on growth and yield performance of Mint at the Department of Agronomy, Faculty of Agriculture, Ariviyal Nagar, Kilinochchi during January to March in 2019. Two factor factorial experiment was carried out in Complete Randomized Design (CRD) with five replicates. Six potting media (M_1 - Cattle manure + Top soil, M_2 - Compost + Top soil, M_3 - Coir dust + Top soil, M_4 - Partial burnt paddy husk + Top soil, M_5 - Goat manure +Top soil, M_6 - Top soil)) and four cutting lengths (L_1 – 6 cm, L_2 – 9 cm L_3 – 12 cm and L_4 – 15 cm) were used as treatment combinations. Growth, yield parameters and chemical properties were recorded and data were analyzed using ANOVA procedure in SAS. The means were compared by using Duncan Multiple Range Test. Management practices were performed according to the farmer practices. There was a significance difference in growth parameters (Plant height, number of leaves, leaf area, branch number, root length and shoot length), yield parameters (fresh weight of shoot , fresh weight of root and number of stolon) and quality parameter (chlorophyll content of leaves) of mint among rooting media and length of cutting. There was an interaction effect between rooting media and length of cutting in all parameters. The plant height, leaf area, length of shoot, fresh weight of shoot and number of stolon were highest in goat manure medium. The leaf number, branch number, root length, fresh weight of root and chlorophyll content were highest in compost medium. A greater yield was recorded in both compost and goat manure media compared to others while goat manures gave more yield than the compost medium. Fifteen centimeter length of cutting showed the best performance and gave the highest yield. It can be concluded that 15 cm length of mint cuttings in goat manure medium can be recommended for the production of mint under the tested conditions.

Keywords: Length of cutting, Mint, Parameters, Rooting media

Effect of Organic Sources and Inorganic Nitrogen on Productivity and Profitability in Transplanted Rice

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Field experiments were conducted at the Tamil Nadu Agricultural University, Coimbatore in *Kharif* and *Rabi* seasons of 2011-12 and 2012-13 to find out the influence of different organic sources and inorganic N fertilizers on rice productivity and profitability. The experiment was conducted in Randomized Block Design (RBD) with three replications. The soil type was clay loam. The results clearly indicated that integration of 50 % N as organics through *Sesbania aculeata* with 50 % N as inorganic (Urea) increased the yield by 24 percent in kharif and 25 percent in rabi rice combination. The available N, P, K and organic carbon contents were increased in the above treatment as compared to 100 % N through inorganic alone. Observations on growth, yield, available nutrient status and economics were taken during the period of investigation. Application of 50 % N through *Seshania aculeate* + 50 % N as inorganic fertilizer gave higher net return and benefit cost ratio of Rs. 58261 and 62921 ha^{-1} and 2.94 and 2.87 during 2011-12 and 2012-13 respectively in the *kharif* and *rabi* seasons. Thus in conclusion, application of 50 % N as organics @ 2000 kg/ha through *Sesbania aculeata* with 50 % N as inorganic @ 163 kg/ha Urea registered higher productivity with enhanced economic returns and soil fertility status in transplanted rice.

Keywords: Inorganic N, Soil fertility, Press mud, Poultry manure, *Sesbania aculeate*

Weed Management through Soil Seed Bank Depletion by Alternate Poly Mulching

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Herbicides are the most effective but least ecofriendly method in weed management. An eco-friendly method of weed control are essential in organic farming and inorganic farming as well. A preliminary study proved that application of a polythene (gauge 150, black colour) mulch for 30 days period controlled the exisisting-germinated weeds from emerging in the field and after removing the polythene mulch almost all the weed seed lot in soil seed bank germinated once due to breaking of seed dormancy. This allows post-emergence weed control to be more efficient. Based on the results of this preliminary study; a field experiment was conducted in order to see the possibility of weed management through soil seed bank depletion by alternate polythene mulching during *Maha* 2017/18 and *Yala* 2018 seasons at Rice Research and Development Institute, Batalagoda. Three treatments namely; (T_1)= Polymulching for 30 days after 01st ploughing followed by allowing seedling emergence for 10 days, followed by a 2nd ploughing followed by all other practices without herbicides, (T_2)= Polymulching for 30 days without 1st ploughing followed by allowing seedling emergence for 10 days, followed by polymulching for 2 weeks followed by seed sowing followed by all other practices without herbicides and (T_3)= Conventional practice which includes 1st ploughing, 2nd ploughing, puddling and levelling followed by seed sowing followed by all other practices including herbicide application (control) were compared. All crop management practices were done according to the recommendation of the Department of Agriculture. Weed counts, weed biomass and final rice grain yield were recorded. Data was analysed employing ANOVA and GLM procedures using SAS software. Total weed biomass of T_1 was significantly lower (35.88 g/m^2) compared to that (41.38 g/m^2) of Control during *Maha* and the total weed biomass of T_1 was comparable (56.11 g/m^2) compared to that (43.31 g/m^2) of Control during *Yala*. Final grain yields of T_1 showed significantly higher (4.78 t/ha) compared to that (4.56 t/ha) of control during *Maha*. Results revealed that polymulching for 30 days after 1st ploughing followed by allowing seedling emergence for 10 days followed by a 2nd ploughing followed by all other practices without herbicides could be effectively practiced to manage weeds in rice as an alternative to conventional herbicide application.

Keywords: Alternate poly-mulching, Conventional practice, Seed bank depletion

Impact of Different Burial Depths on Weedy Rice (*Oryza sativa* f. *spontanea*) Seedling Emergence

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Direct seeding of rice is widely adopted in Sri Lanka due to the scarcity of land and labour. Weedy rice (*Oryza sativa* f. *spontanea*) is a serious problem in direct-seeded rice. Lack of selective herbicides for the control of weedy rice, nor other effective measures, has made its control a subject of national significance. The ability of emergence of eight Sri Lankan weedy rice populations, collected from different geographical regions buried in 3, 6, 9 and 12 cm depths was assessed. The experiment was conducted twice, in a Randomized Complete Block Design in an open field. Ten seeds of each accession were placed on the soil surface of plastic pots with three replicates. Seedling emergence was recorded for 28 days. ANOVA analysis indicated that the interaction effect of population*burial depth was not significantly affected by the seedling emergence. Burial depth had a significant impact on seedling emergence. Seedling emergence gradually decreased with increased burial depth, with minimal emergence from a depth of 12 cm. Burial depth of 3 cm and 6 cm recorded the highest seedling emergence. Burial depth of 9 cm noted moderate emergence. The results of this study suggest that weedy rice seedling emergence can be suppressed by deep tillage thereby burying the seeds below the maximum depth of emergence, followed by flooding fields to create anaerobic conditions. Our findings provide a new clue for developing agronomic practices, adopt to the deep ploughing techniques is vital to minimize the continuous enrich of weedy rice seeds in the prevailing soil bank.

Keywords: Burial depth, Direct seeding, *Oryza sativa* f. *spontanea*, Weed control

Effect of Time of Planting on Growth, Flowering Efficiency and Yield of Different Onion Cultivars in *Maha* Season

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Onion (*Allium cepa* L.) is an important cash crop in Sri Lanka, cultivated by either seed or bulb. Seed production of onion is important due to global demand of onion and lack of good quality planting materials at affordable price. The field experiment was conducted in Regional Agricultural Research and Development Centre, Kilinochchi, to evaluate the effect of planting time on growth, flowering efficiency and yield of different varieties of red onion cultivars in *Maha* season during November 2018 to March 2019. The experiment was carried out in factorial Randomized Complete Block Design with three replicates. Four different times of plantings [20th (P_1), 30th (P_2) of November and 10th (P_3), 20th (P_4) of December 2018] and one standard variety MICLO 1(V_1) with two selected cultivars [Vethalam (V_2), TVM 6(V_3)] of red onion were used as treatment combinations. Altogether twelve treatment combinations were tested with three replicates. Management practices were performed as per the recommendation of Department of Agriculture, Sri Lanka. Growth and yield parameters were recorded. Data were analysed by ANOVA using SAS 9.1 package. The means were separated by Duncan Multiple Range Test. The results revealed that the planting time had positive and negative significant effects on growth parameters (plant height, number of leaves, number of days to fifty percentage flowering, stalk length and umbel diameter) and yield parameters (seed weight per umbel, total seed weight and total dry bulb weight) of onion. Among the treatment combinations, cultivar TVM 6 planted on November 20th had high significant seed yield (0.3695 t/ha) than that of other treatment combinations. The differences in seed yield among planting time and variety were significant but there was no interaction ($P \leq 0.05$) between planting time and variety. It can be concluded that variety TVM-6 and planting date of November 20th could be the best combination for growing of red onion in Kilinochchi District during *Maha* season based on the finding of this study.

Keywords: Onion, Parameters, Planting time, Seed production, Variety

Pre and Post-Harvest Losses of Cashew (*Anacardium occidentale* L.) in Batticaloa District, Sri Lanka; Preliminary Investigation of the Causes

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The cashew nut industry in has great economic importance in the developing countries like Sri Lanka, in the local and global market. However, the market price per kilogramme of the nuts reveals, the demand for cashew nut and the gap between need and the production. Though, Batticaloa is one of the major districts for cashew production in Sri Lanka, no studies have been undertaken to estimate the postharvest losses and the causes of such losses. Hence, a survey was conducted to find out the possible reasons for pre and post-harvest losses of cashew nut and apple in Batticaloa district. The survey was conducted in five Divisional Secretariat (DS) with 95 individual questionnaires. The semi-structured questionnaires were carried out through opportunistic non-random sampling (Convenience sampling) method, interviewing cashew farmers, cashew nut and apple sellers. Key informant interviews and field verification were also conducted during this study. Descriptive statistics and the one- way ANOVA were used to analyse the data, statistically. The study revealed that the average production of cashew nut/tree/year is 8.63 kg. The unorganized orchards, poor cultural practices, old heterogeneous population of trees and poor or low yielding varieties are some of the major reasons for poor yield. In addition, 15 % of loss occurs due to the natural enemies, including parrots, bats, *etc*. Further, the results showed that poor harvesting, drying and storing practices also contribute to the postharvest losses. The survey revealed that majority of the farmers discard the cashew apple after collecting the nuts. Hence, awareness on management of cashew plantations, introduction of improved verities and proper pre and post-harvesting practices are some of the vital aspects to enhance the cashew industry. In addition, improve the value-added products of cashew apple could also lead to have better economic returns to the local industries.

Keywords: Cashew Nut and Apple, Pre and postharvest management practices, Value-added products

Livestock, Poultry Management, Aquaculture and Fisheries

Identification of Bovine Mastitis Causing Bacteria and Possible Antibiotic

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Mastitis is an inflammation of mammary gland. It is the most prevalent production disease in dairy herds world-wide and under untreated conditions, it constitutes a serious problem in dairy herds with considerable economic consequences, mainly due to fall in milk production, decreased milk quality for dairy purposes and poor milk hygiene. Livestock is an important traditional economic activity and is integrated with crop cultivation in Kilinochchi district. This sector considered as major source of income for farming society in the region. The present study was carried out to identify the mastitis causing bacteria and identify possible antibiotics for the CMT positive bacteria in Kilinochchi district from November 2018 to March 2019. A total of 136 (n=136) lactating cows were randomly selected to identify the mastitis from four veterinary ranges in Kilinochchi district. Karachchi (n=32), Kandawalai (n=42), Poonakari (n=39) and Pachchilaipalli (n=23) were the veterinary divisions in Kilinochchi district and sampling was done in all four ranges. Milk samples were screened for mastitis by using California Mastitis Test (CMT). The CMT positive samples were subjected to isolation and identification of bacteria and also subjected to Antibiotic Sensitivity Test (ABST). Result showed that 14.7 % (n=20) lactating cows were positive to CMT. All positive samples were inoculated in the nutrient agar medium and showed colony formation. For the identification of Gram positive and Gram negative bacteria, single colony was subjected to catalyst test. Catalase positive reaction was confirmed by immediate effervescence (bubble formation) formation from all 20 samples indicating presence of Gram positive bacteria. From all CMT positive milk samples, only one bacterial agent, *Staphylococcus* spp. was isolated. From the Antibiotic Sensitivity Test result, 35 % (n=7) of bacterial isolates were sensitive to Enrofloxacin while 25 % (n=5) of bacterial isolates were sensitive to Cloxacillin.

Keywords: Inflammation, Mastitis, *Staphylococcus*, Udder infection

Prevalence of Brucellosis among the Cattle in Kilinochchi District

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Brucellos is one of the most contagious, communicable and zoonotic disease with high rate of morbidity and lifetime sterility in cattle and it leads to significant economic losses. Brucellosis occurs throughout the world and can spread animal to human. In recent years Brucellosis has increased in intra/ inter specific infection rates due to its poor management mostly in developing countries. A cross section study was conducted to investigate the prevalence of brucellosis in Karachchi, Kandawalai, Pachilaipalli and Poonagary veterinary divisions of the Kilinochchi district during the period of end of October 2018 to early April 2019. The objectives of the study were, determine the prevalence of brucellosis in Kilinochchi district, to study the brucellosis among different breeds of cattle combined with different lactation cycle and to study the risk factors associated with brucellosis. Among the 2562 cattle farms in Kilinochchi district, 208 farms were randomly selected for the study using table of random numbers. 208 individual milk samples and 72 bulk milk samples, 95 blood samples were tested for brucella antibodies using Milk Ring Test (MRT), Rose Bengal Plate test (RBPT) and Complement Fixation Test (CFT). The overall prevalence of brucellosis cattle in Kilinochchi district was 10.6 % (n=29). Prevalence of brucellosis was higher in Karachchi division compared to other veterinary divisions. 18.8 % (n=29) were positive for MRT in Kilinochchi district. Among these MRT positive samples, 20.0 % (n=14) were from 1st lactation, 12.0 % (n=9) were from 2nd lactation, 16.7 % (n=6) were from 3rd lactation and 37.0 % (n=10) were from 4th lactation. Among the blood samples 12.5 % (n=26) were positive for RBPT. Among these positive results (MRT, RBPT) 10.6 % (n=29) were positive for complement fixation test (CFT). Prevalence of brucellosis was higher in jersey cross breeds (15 %, n=17) compared to other breeds (sahiwal 3.7 %, local breed 8.2 %) in Kilinochchi district. Risk factors associated with brucellosis were abortion history and retained placenta. Brucellosis is an important livestock disease in Kilinochchi.

Keywords: Brucellosis, Complement fixation test, Milk ring test, Reproductive disorders, Rose Bengal plate test

Spatial and Diurnal Variation of Plankton in Pallikudawa Bay Coastline Tangalle; Southern Sri Lanka

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Plankton abundance and diversity in upper and lower water layers in Pallikudawa bay were studied at different time periods (*i.e.* 8.00–10.00 am, 10.00–12.00 noon, 12.00–2.00 pm, 2.00–4.00 pm) for three months (May-June) in 2018. The water quality parameters (*viz.* temperature: ^{o}C, turbidity: NTU and salinity ppm) were measured at seven selected locations within the bay at each time interval. The 55 µm mesh size cod – end of plankton net was used to filter water samples. The filtered water samples were fixed in lugol's solution and then used for identifying phytoplankton whereas the water samples were fixed in 5 % formalin were used for identifying zooplankton. The highest upper layer abundance of phytoplankton (± 182.2) was observed at the time interval of 12.00–2.00 pm and minimum abundance (± 105.6) was found at the time interval of 2.00-4.00 pm and showed a significant diurnal variation (two-way ANOVA: $P < 0.05$). Mean Phytoplankton Diversity (MPD) of the upper layer (Shannon-Weiner index) showed the highest diversity during 12.00 – 2.00 pm (± 2.074) and the lowest diversity during 8.00–10.00 am (± 0.508). Similarly, in the lower water layer, the MPD changed significantly over the time duration (one-way ANOVA: $P < 0.05$). Mean zooplankton diversity (MZD) was also highest during 12.01-2.00 pm (± 2.896) in upper layer while the lowest diversity was observed during 8.00-10.00 am (± 1.223). MZD of lower layers showed the highest during 2.00-4.00 pm (± 3.60). The 112 plankton species was recorded and among them, 40 phytoplankton species and 27 zooplankton species were identified during the study. The data of this baseline study shows high diversity of plankton in the Pallikudawa bay during the study period.

Keywords: Abundance, Diversity, Phytoplankton, Pallikudawa bay, Zooplankton

Comparison of Nutritive Value of Widely Used Feed Materials for Feeding Dairy Cows in Kilinochchi District, Sri Lanka

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A study was conducted to examine the nutritive value of the major roughages and concentrate feed materials used for feeding dairy cows in the Kilinochchi district, Sri Lanka. The most widely used feed materials were identified using a pre-tested structured questionnaire from eighty medium-scale (*i.e.* 20-25 L milk yield per day and herd size of 10-15 cows) dairy farmers. Based on the statistical analysis, six concentrates (gingelly (*Sesamum indicum*) cake, coconut (*Cocos nucifera*) cake, dairy mash (CIC), wheat (*Triticum aestivum*) bran, rice (*Oryza sativa*) bran, dhal (*Lens culinaris*) husk)) and six roughages (CO-3, *Pennisetum americanum* × *Pennisetum purpureum*), sugar graze (*Sorghum bicolor*), azolla *(Azolla pinnata)*, groundnut (*Arachis hypogaea*) leaves, gliricidia *(Gliricidia sepium*), and paddy straw) were chosen for the analyses of chemical composition and *in vitro* digestibility of nutrients using standard protocols. Among the concentrates, gingelly cake had the highest ($P < 0.05$) percentage of Crude Protein (CP) (41.52 % DM), ash (13.89 % DM) and *In-vitro* dry matter digestibility (DMD) (70.32 % DM), whilst dairy mash had the highest metabolisable energy content (ME) (10.98 MJ/kg DM). Among the roughages, the highest ($P < 0.05$) percentage of CP (29.74 % DM) and ash (20.91 % DM) and lowest percentage of neutral detergent fiber (NDF) (16.64 % DM) were observed in azolla while paddy straw had the lowest percentage of CP (4.12 % DM) and DMD (34.43 % DM). Data collected from the current study, coconut poonac, gingelly poonac, wheat bran and dairy mash were identified as both energy and protein supplementing concentrates. Whereas azolla can be used as a protein supplement and gliricidia can be used as both energy and protein supplementing roughage.

Keywords: Concentrates, Feed resources, Nutritional value, Roughages

Effect of Commercial Meat Tenderizer (*Bromelain*) on the Sensory Attributes of Goat Meat Chunks

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Bromelain is a protease enzyme extracted from pineapple, which is used as a natural meat tenderizer. The study was aimed to identify the optimum concentration of commercial tenderizer bromelain for the goat meat (*Capra aegagrushircus)* chunks. Bromelain solutions were prepared in different concentrations on weight/volume basis (0.2, 0.4, 0.6 and 0.8 %). Approximately fifty grams (50 + 2) of carcasses from same part were chosen and the pH and the initial weight of the meat chunks were measured. The goat meat chunks were marinated in the bromelain solutions for 24 hours at 4 ^{O}C and the control sample was allowed to marinate in the distilled water. The chunks were taken out and mixed with 2 % (w/w) salt followed by the thermal treatment at 121 ^{O}C for 15 minutes. The pH, weight difference of the meat chucks and the rigidity index after thermal treatment were measured. Sensory attributes (Juiciness, tenderness, flavor, colour and overall acceptability) of the heat treated chunks were evaluated using Hedonic Scale (9 points) with thirty semi-trained panelists. The results emphasized that the pH of the goat meat significantly decreased ($P < 0.05$) with the increasing concentration of bromelain. Thermal yield of the treated meat chunks was significantly lower ($P < 0.05$) than the control. Rigidity index of bromelain treated meat chunks was significantly higher ($P < 0.05$) than the control. The sensory score exhibited that the lower concentration (0.2 %) of bromelain was sufficient to tenderize the goat meat chunks and over tenderization (pasty texture) was observed in higher concentrations (0.6 % and 0.8 %). The overall acceptability (mean ± SD) of the treated goat meat chunks were recorded as 8.33 ± 0.77, 5.67 ± 1.15, 3.17 ± 0.71 and 2.83 ± 0.71 for 0.2, 0.4, 0.6 and 0.8 % of concentrations respectively. The control sample was scored 4.67 ± 0.78. Based on the sensory analysis, the concentration of 0.2 % was the optimum concentration to tenderize the goat meat.

Keywords: Goat meat chunk, Meat tenderizer, Optimization

Development of *Aloe vera* Juice Incorporated Herbal Milk Beverage

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The inclusion of physiologically active natural components with health beneficial properties, strengthens the value of milk beverages. *Aloe vera* is one of the oldest known medicinal plant gifted by nature and currently, the interest and use of *A. vera* as a functional ingredient has increased tremendously. The addition of *A. vera* juice makes it possible to produce functional foods from milk, by preserving their chemical, physical and sensory characteristics and enhancing nutritional value. In this backdrop, the present study was carried out to develop a novel herbal milk beverage for commercialization to satisfy the needs of health-conscious consumers. The natural *A. vera* is *barbadensis millar* extract was used as the functional ingredient. The product was developed by incorporating different levels of sugar (3–9 %), pH (3.00–4.50) levels and flavors (almond and ginger). The organoleptic properties such as appearance, flavor, aroma, texture/mouth feel, overall taste, and overall acceptability were studied. The final product was formulated and improved according to consumer preference based on sensory evaluation. The proximate composition of the product was evaluated by standard analytical methods. All the sensorial parameters which were tested in the formulated product scored above 7.0 in nine-point-hedonic scale which revealed that the product was towards the "extremely-like" category. *A. vera* incorporated herbal milk beverage was accepted by the sensory panelists, therefore could consider as appealing to consumers as well. The proximate composition matched with Food Act No. 26 of 1980 for raw and processed milk. The product was appropriate for commercialization in terms of consumer preference and production cost.

Keywords: *Aloe vera*, Consumer, Functional

Prevalence of *Listeria monocytogenes* in Raw Milk and Dairy Products in Pannala Veterinary Division

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Listeriosis is a severe foodborne disease caused by the consumption of contaminated food along with *Listeria monocytogenes*. A large variety of food, especially dairy products and ready to eat foods can support the growth of *L. monocytogenes* bacteria. Listeriosis outbreak has been associated with consumption of milk, cheese, vegetable salads, and meat products. Therefore, this study was conducted to determine the presence of *L. monocytogenes* in raw milk and dairy products available in Pannala veterinary division. A total number of 66 samples, comprising 30 raw milk samples collected from 10 milk collecting centers, 36 dairy products; namely ice cream (n=12), flavored milk (n=12) and Ultra-High Temperature processed (UHT) milk (n=12) were used in this study. Samples were microbiologically analyzed by following the methods recommended by ISO 11290-1:2017 to isolate *Listeria* species. Buffered *Listeria* enrichment broth was used for selective enrichment and then enriched culture was inoculated to the standard selective differential HiChrome™ *Listeria* agar medium to identify and isolate the *L. monocytogenes* based on phenotypic characteristics. Isolates were further analyzed using Gram's staining and hemolysis test for the confirmation of *L. monocytogenes*. The result of this study revealed that overall, 41 % (27/66) of total studied samples were contaminated by *L. monocytogenes* including 37 % of raw milk, 58 % of ice cream and 33 % of flavored milk samples and no *L. monocytogenes* was detected in UHT milk. In conclusion, prevalence of *L. monocytogenes* in raw milk and dairy products has a potential public health risk, due to prevalence of *L. monocytogenes* in raw milk and dairy products. Further, molecular studies are required to confirm the presence of *L. monocytogenes* in biochemically identified isolates.

Keywords: Dairy products, *Listeria monocytogenes,* Raw milk

Genetics, Plant Breeding, Plant Protection and Biotechnology

Estimate of Heterosis and Heritability of Some Yield and Growth Characters of Bread Wheat (*Triticum aestivum* L.) Varieties in Wudil, Nigerian Sudan Savannah

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The field experiment was conducted at Kano University of Science and Technology Wudil, Gaya research farm under irrigation conditions to estimate the heterosis and heritability of five different bread wheat varieties. The treatment consists of five different bread wheat varieties; Atilla (AT), Borloug (BO), Seri (SE), Reyna 28 (RE) and Pavan (PA) and was replicated three times using Randomized Complete Block Design (RCBD) with space isolation. Genotypes are significantly different for the mean average for plant height, number of tillers per plant, number of spikes per plant, number of grains per spike, number of leaves per plant, length of the spike, length of the root, weight of grain and 1000 grain weight. The maximum heterosis and heritability were recorded in AT x SE (13.89 cm) and RE x PA (97 cm) for plant height, AT x RE (25.9) and BO x PA (90.0) for number of tillers per plant, BO x PA (29.86) and BO x PA (90.0) for number of spike per plant, PA x RE (8.71) and BO x RE (95.7) for number of grain per spike, SE x RE (1.89 cm) and BO x RE (96.7 cm) for length of spike, BO x AT, BO x SE and AT x SE (11.11 cm) and BO x SE (87.5 cm) for length of roots, AT x SE (74.0 g) and AT x RE (93.3 g) for weight of grain per spike and BO x SE (9.16 g) and BO x SE, AT SE (86.5 g) respectively. According to the results, it could be concluded that the cross combination of BO x AT recorded better agronomic performance and greater mean values of yield and weight. It showed a significant positive heterosis and very high to moderately high heritability. Thus, the hybrid combination could be recommended for improve yield and enhance biological production of wheat plant. Therefore, Borlaug and Atilla varieties are strongly recommended for commercial production under the local environment of Wudil, Kano state of Nigeria.

Keywords: Bread wheat, Growth characters, Heritability, Heterosis, Yield

Optimum Density of Callus Inoculum and Sub-culturing Interval in Callus Culture of *Gyrinops walla*

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Gyrinops walla is an endemic and endangered species of Sri Lanka, produces precious fragrant resin infused wood called, agarwood. *In-vitro* callus culture of *G. walla* is the best and viable alternate to produce fragrant compounds commercially, while conserving the existing species. The present study was aimed to select optimum inoculum density and subculture interval in callus culture, which would be the foremost and determining step of successful callus culture and product synthesis. In the present study, five different densities of callus inoculums (100, 150, 200, 250 and 300 mg on fresh weight basis) were examined to choose the best inoculum density from the growth curves. Callus specific growth rate (mg/week) were calculated by regressing natural logarithms of callus dry weight overtime and doubling time were calculated by dividing the growth rate by 0.693. Highest cell biomass was assessed from the point where exponential growth declined. Sub-culturing frequency was determined as at which point the stationary phase commenced in the growth curve. Among the treatments, 200 mg fresh weight of callus was chosen as the optimum initial inoculum density with highest specific growth rate (398.3 mg/week on dry weight basis), fastest cell doubling time (1.74 weeks) and maximum cell biomass (128 mg dry weight). Sub-culturing interval was decided as end of six weeks of inoculation. Present study concluded that 200 mg fresh weight of initial inoculum density and six weeks of sub-culturing interval should be considered during the periodic sub-culturing of callus to maintain the healthy and alive culture with the ultimate aim of producing fragrant compounds through *in vitro* cultures of *G. walla*.

Keywords: Callus, Cell-doubling time, Inoculum density, Sub-culturing frequency, Specific growth rate

Morpho-Physiological and Yield Characteristics of Interspecific Hybrids between Cultivated Eggplant (*Solanum melongena* L.) and Wild Relatives in Response to Drought Stress

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Drought has been identified as one of the principal global problems, which further exacerbates under climate change. Crop wild relatives are a genetic resource with an array of traits of interest, including tolerance to biotic and abiotic stresses. The aim of this study was to evaluate the drought tolerance of ten interspecific hybrids between seven different cultivated varieties of *Solanum melongena* L. and three wild relatives (*Solanum insanum, Solanum incanum* and *Solanum lichtensteinii*). The experiment was conducted in a protected house at the University Research Station, Meewatrura, Peradeniya (WM2b) during *Maha* 2018. The experimental materials were subjected to three irrigation treatments *viz*: field capacity (control, I_1) and two droughts stress levels (70 % and 40 % of field capacity: I_2 and I_3). Plant morphological characters, physiological characters and yield attributes were measured. Results revealed that drought stress (I_2 and I_3 treatments) significantly ($P \leq 0.05$) reduced the plant height, canopy width, number of leaves, number of branches, number of fruits and finally the average yield of all interspecific hybrids. The proline content and chlorophyll concentrations (a, b and total) were significantly increased ($P \leq 0.05$) in the plants under the drought stress. Relative water content also significantly increased ($P \leq 0.05$) for I_3 level. Total soluble solids of fruits were increased significantly ($P \leq 0.05$) due to the drought stress. Moreover, interspecific hybrids MEL2 × INS1, MEL3 × INS1, MEL5 × INS1, MEL6 × INS1 and MEL7 × INS1, have shown better performance under I_1 and I_2 treatments while, MEL2 × INS1, MEL3 × INS1, MEL5 × INS1, MEL6 × INS1, MEL7 × INS1 showed best tolerance under I_3 treatment. Thus, those interspecific hybrids have potential to utilize as genetic materials for future breeding programs to develop drought resistant eggplant varieties.

Keywords: Drought stress, Eggplant, Interspecific hybrids, *Solanum incanum, S. insanum, S. lichtensteinii, S. melongena*

Nutritional Characterization of Horse Gram (*Macrotyloma uniflorum* Lam. Verdc.) Germplasm Accessions

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Horse gram (*Macrotyloma uniflorum* Lam. Verdc.) is an under-exploited multipurpose legume being cultivated in wide range of environmental regimes. The seeds are enriched with protein, carbohydrate, iron, molybdenum, phosphorous and vitamins *viz*., thiamine, vitamin C, niacin, carotene and riboflavin. Horse gram also plays an important role in Indian ayurvedic medicine which cures many ailments. It is popularly known as poor man's pulse crop in India because of its increased nutritional benefits coupled with adaptable tolerance mechanism to various abiotic stresses. Though large germplasm deposits are available in Indian gene banks, the negligence in characterization/ evaluation limits the crop improvement programme in horse gram. An experimental study was conducted with 252 horse gram accessions retrieved from Dr. Ramaiah gene bank, Tamil Nadu Agricultural University, India. Data on 12 biometrical traits were utilized to estimate genetic divergence by employing Mahalonobis D^2 statistic. The genotypes were grouped into 25 clusters based on Tochers's method. The representative sample from each cluster was selected based on comparison of *per se* value of single plant yield with respective cluster mean. A total of 25 genotypes involving a local check *viz*., PAIYUR 2 was considered for estimation of crude protein, fat and fibre content. These nutritive components decide the suitability of horse gram flour for diet and health mixture preparations. A significant range of variation was observed between horse gram clusters for crude protein (19.25 % - 25.69 %), fibre (2.00 % -2.60 %) and fat content (0.82 % - 1.16 %). One promising accession *viz*., PLS 6219 (Cluster XII) was identified with high protein content of 25.69 % which could be employed in future nutritional breeding programme. Among nutritional contents, the highest variability was noticed in crude fat (8.44 %) followed by crude fibre (7.31 %), which provides a scope for evolving high yielding genotypes with enriched nutrient value in near future.

Keywords: Horse gram, Germplasm, Nutritional characterization

Combined Breeding Strategies for Variability Evolution in Horse Gram (*Macrotyloma uniflorum* Lam. Verdc.)

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Horse gram (*Macrotyloma uniflorum* Lam. Verdc.) is known as the poor man's pulse crop of India and serves as ingredient in many traditional medicines. It is cultivated in marginal lands under rainfed situation for food and fodder. The yield of horsegram is reduced by its indeterminate growth habit and relatively long crop duration. Indeterminate growth produces green immature pods at harvest. Long duration exposes the crop to terminal drought at flowering/ maturity phase. Therefore, this attempt was made to generate early maturing genotypes with determinate growth habit through classical breeding and combination of classical hybridization and induced mutagenesis. Two well adopted cultivars *viz.,* PAIYUR 2 and CRIDA 1-18R, and two early maturing germplasm lines *viz*., PLS 6202 and PLS 6211, were used in generating genetic variation through classical and combined breeding approaches (*i.e.* classical + mutation breeding). Fifty percent of the true F_1's were chemically mutated with 0.3 % EMS (Ethyl Methane Sulphonate). The F_1's and F_1M_1's were compared for yield attributing traits during *rabi* 2018. Of the two breeding methodologies employed, F_1M_1's were found to be promising for yield related traits and earliness. Among the four F_1M_1's, crosses involved the donor parent PLS 6211 were found to be hopeful for yield attributing traits as it had exhibited positive heterosis for earliness and yield. The mean values for single plant yield ranged from 19.58 g to 25.50 g and 18.45 g to 23.53 g in the F_1M_1's involving donor parent PLS 6211. This yield patterns were significantly greater than the donor parent but lesser than the recipient parents (PAIYUR 2: 27.50 g; CRIDA 1-18 R: 24.27 g). Of the two breeding methodologies employed, combination of classical breeding and induced mutagenesis was found to be better for generating variability for duration and yield.

Keywords: Classical hybridization, Horsegram, Induced mutagenesis, Variability evolution

Augmenting the Antagonistic Potential of Consortia of Bio-Control Agents and Organic Amendments to Combat Dry Root Rot in Black Gram (*Vigna mungo*) Caused by *Rhizoctonia bataticola*

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The production of pulses in India has been hampered by many biotic and abiotic stresses. The diseases afflicting pulses including black gram have increased the cost of cultivation of farmers thereby render them indebted. In order to help pulse farmers with a cost effective method to tide over dry root rot in blackgram (*R. bataticola*) a study was commissioned with the objective of developing and testing the efficiency of a consortia of bio-control agents in controlling root rot. The study results revealed that, among the ten *Trichoderma* isolates tested, TvL1 recorded the least mycelial growth with 55.6 % inhibition over control. Out of twenty *Pseudomonas* isolates tested, PfUL(A) recorded maximum inhibition (41.1 %) of *R. bataticola* mycelial growth whereas the isolate *Bacillus subtilis* BsOP2 recorded maximum inhibition (44.4 %) of growth of mycelia of root rot. The result from the pot culture experiment revealed that the mixture of PfUL(A) + BsOP2 + neem cake + farm yard manure (95 %) reduced the disease incidence to 20 % and this combination recorded significantly higher germination percentage when compared to control (71.7 %). The greatest reduction in per cent disease incidence of dry root rot was observed in plots treated with the mixture of PfUL(A) + BsOP2 + neem cake + FYM (25.65 %) followed by PfUL(A) + TvL1 + neem cake + FYM (29.0 %) compared to the untreated control (55.85 %). The percent disease index recorded with respect to chemical control was 24.85 %, which indicated that it was on par with the biocontrol agents in terms of reducing disease incidence. Despite the chemical treatment fared well in reduction of disease, the biocontrol agents are preferred over chemical treatment due to their environmental friendliness. The study results reaffirmed that the consortia of bio control agents PfUL(A) + BsOP2 along with neem cake and FYM were found to be effective in controlling the dry root rot disease in black gram.

Keywords: Bio control agents, Black gram, Dry root rot, *Rhizoctonia bataticola*

Efficacy of Citronella (*Cymbopogon nardus*) Leaf Extract on Maize Weevil (*Sitophilus zeamize*) Infestation for Stored Maize in Sri Lanka

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Damage of S*itophilus zeamize* on stored maize is a concern among Sri Lankan maize growers, traders and consumers. With the increased awareness on health and environmental consequences associated with synthetic insecticides there is growing demand for alternate insect control strategies. Use of botanicals with essential oils can be considered as a potential alternate therefore Citronella grass (*Cymbopogon nardus)* was identified as a potential plant species for controlling of *S. zeamize.* This study was conducted with the objective of evaluating the efficacy of Citronella grass aqueous leaf extract against Maize weevil, *S. zeamize.* Area preference bioassay was conducted for the laboratory scale repellency analysis under five treatments that was a dilution series of the citronella aqueous leaf extract; 15, 20, 50 and 100 µL/mL and control (distilled water). Repellency index was developed and three dilutions with higher repellency index were selected for storage trial. Selected three treatments (20, 50 and 100 µL/mL) were tested using distilled water as the control. Experiment was conducted under temperature 32^{o}C ± 1.4 and RH 60 % ± 7. Mass loss due to insect damage was considered as the main parameter for the analysis of insect damage until loss of marketability. Experimental results revealed that the insect damage was significant for all the treatments ($P < 0.05$) and it was significantly increased with the storage time period. Furthermore, no significant difference of mass loss due to insect damage ($P > 0.05$) among the treatments and control was observed after one month, two months and three months of storage periods. Hence, it can be concluded that, selected dilutions of citronella aqueous leaf extract were not effective in controlling maize weevil. Most probably, it may be due to the volatile nature of active compounds of citronella grass leaf extract. Future research could be planned to investigate the same volatiles coupled with a slow volatile release mechanism.

Keywords: Botanicals, Citronella, Insect damage, Maize weevil, Storage pests

Determination of Potential Larvicidal Activity of *Parthenium hysterophorus* L. Leaf Extracts against *Aedes aegypti*

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Dengue is a mosquito born viral disease, severely affected most people in the world. Use of phytochemical to control mosquitoes is an eco-friendly method than the application of synthetic insecticides. The study was undertaken to determine the potentiality of larvicidal activity in *P. hysterophorus* L. (Parthenium) leaves extracts against *A. aegypti* larvae. The dried powder of Parthenium leaves was obtained and subjected for sequential extraction method in Soxhlet apparatus using hexane, ethanol and water for 24 hours seperately. Crude extracts were evaporated in rotary evaporator and obtained dried crude extracts and stock solutions were prepared. Based on preliminary study, five different concentrations (0.1, 0.2, 0.3, 0.4 and 0.5 %) were prepared from each stock solutions and *A. aegypti* larvae (10n) were introduced in triplicate to dertermine the mortality after 48 and 72 hours of exposure duration. The distilled water was used as control. LC_{50} and LC_{90} values were determined for each extract at 48 and 72 hours of exposure. Data was analyzed by using SPSS 22.0 statistical package. Duncan Multiple Range Test (DMRT) was used to compare the means of larval mortalities with different concentrations and exposture duration. The larval mortality was significantly increased with the time and concentrations of the leaves extracts ($P < 0.05$). The least LC_{50} and LC_{90} values were observed in water extracts at 48 hours (LC_{50} and LC_{90}: 146.43 ppm and 389.71 ppm), while the ethanol extract had the least values at 72 hours (LC_{50} and LC_{90}: 132.84 ppm and 329.30 ppm). Hexane extract showed highest LC_{50} and LC_{90} values in all exposure durations compared with other solvent extracts. The study shows that *P. hysterophorus* L. leaves extracts have larvicidal activity against *A. aegypti* larvae.

Keywords: *Aedes aegypti,* Larvicide, *Parthenium hysterophorus,* Sequential extraction

Sustainable Waste Management: Green Concept of Black Solider Fly Larvae; *Hermetia illucens* (Diptera: Stratiomyidae), as Biodegradable Waste Convertor; Comparison of Life Cycle and Growth Performances in Two Different Substrates

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Rapid waste generation is correlating with population growth has led widespread numerous impact on global sustainable development. It is predicted that average waste generation is 0.74 kg/head/day where global waste is expected to be raised into 3.4 billion tons by 2050 along with unplanned urbanization where more than half of the generated waste is open dumped. Viable waste management practices using insects are in trend, but locally less known. The black soldier fly larvae have proven its capability in decomposing the organic matter, controlling the odor emitted by bio waste and using as a protein source in animal feed. The study intends to compare the life cycle modalities of BSFL with the model life cycle in two different substrates, swill – kitchen organic waste (T_1) and poultry starter feed (T_2), reared in a specially designed bin with a volume of 21195 cm^3. The days taken for life cycle completion, eggs characteristics including egg-length and volume, larval characteristics including length and width of different larval instar stages and percentage of Crude Protein (CP %) of pre pupae and 5th instar stage using three replicates were assessed. The experiment conducted under the laboratory conditions of 28˚C average temperature and 60-70 % average relative humidity at IM3 agro climatic region in Belihuloya, Sri Lanka. There was no substrate-dependent effect on the length of egg and volume of egg masses. The total time taken to complete the life cycle in T_2 (37-45 days) was earlier than the T_1 (46-57 days). Substantial length and width variation of different larval instars were noted whereas higher mean values were recorded in T_2. The CP percentage of pre-pupae stage was 51.99 % in T_2 while 39.46 % in T_1. The 5th instar stage of BSF larvae, CP percentage were recorded as 48.88 % and 33.11 % in T_2 and T_1 respectively. In conclusion, poultry starter feed (T_2) which was nutritious and formulated diet, was considered as the most appropriate substrate for early life cycle completion with compared to swill (T_1). Larval growth under T_2 conditions recorded the highest CP levels but it need to be further studied prior to use as protein substitution in animal feed formulation.

Keywords: Black solider fly larvae, Crude protein, *Hermetia illucens,* Poultry starter feed, Swill

Evaluation of Adaptability of Exotic Rice Hybrid Combinations for Low Country Intermediate Zone in Sri Lanka

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Enhancement of rice yield will be needed to fulfill the increasing demand for rice in future. Hetorosis breeding is one of the options to enhance the rice production. Development of hybrids by using exotic hybrid parents is one of the alternatives to increase the rice production in country. Identification of adaptable exotic hybrids for local condition is important to select their parents (Cytoplasmic Genetic Male Sterile and Restorers) to use them for the F_1 seed production under local condition. Therefore this experiment was conducted to find out the most suitable well adopted hybrid varieties for the low country intermediate zone. Five Chinese hybrid varieties (CH13, CH14, CH17, CH18, and CH21) with two local hybrids (Bg 407H, HR10) were evaluated during the *Maha* 2017/18 at Rice Research and Development Institute, Batalagoda. Randomized Complete Block Design (RCBD) was adapted with three replicates. Bg 304 (90 days old), Bg 357 (105 days old) and Bg 403 (120 days old) were used as standard check varieties. Sixteen days old seedlings were transplanted in 3 x 6 m plot at 20 x 15 cm spacing in puddle soil. Grain yield and yield components (1000 grains weight, number of productive tillers per hill, spikelet per panicle, filled grain percentage of panicle) and other important morphological traits were recorded. Exotic hybrid CH18 showed significantly higher grain yield (6.26 t/ha) compared with all exotic, local hybrids and respective stranded varieties. All exotic hybrid varieties showed less maturity days (~100) in local conditions than their maturity days (~120) in the native environment in China. Early maturity is mainly affecting to reduce the vegetative face of varieties and it affect to obtain low yield. CH18 showed highest standard heterosis too (20.15 %) and it was selected as best performing exotic hybrid during the 2017/2018 *Maha* season of the low country intermediate zone under supplementary irrigation condition in Sri Lanka.

Keywords: Exotic hybrids, Inbred, Hetorosis breeding, Standard heterosis

Evaluation of Rice Pest Incidences Associated with Different Plant Establishment Methods in Rice Cultivation

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Rice (*Oryza sativa* L.) is the major food crop in Sri Lanka. Insect pests are one of major constraints in rice production. The insect pest population shows fluctuations depending on various abiotic and biotic factors of an area. The effect of planting methods and plant density on insect pest abundance is varied and complex. There is dire need for change in rice establishment methods to improve productivity, economics and long-term sustainability. Therefore, evaluation of rice pest incidences at different plant establishment methods is an urgent need. Four plant establishment methods; Machine transplanting, Parachute, Seed broadcasting and manual transplanting were studied within 3 consecutive seasons; 2017 *Yala*, 2017/18 *Maha* and 2018 *Yala*. Few major pests occurred during the crop cycle of paddy including rice thrips (*Stenchaetothrips biformis*), leaf folder (*Cnaphalocrocis medinalis*), stem borer (*Scirpophaga incertulas*), gall midge (*Orseolia oryzae*) and paddy bug (*Leptocorisa oratorius*) was counted and temperature, relative humidity and final yield were recorded. The experiment was arranged in a Randomized Complete Block Design with three replicates. The abundance of selected pests in three replicates, each measuring 50 m^2 area of differently established fields were counted. The final results were revealed that, due to high plant density, seed broadcasting establishment method utilized in rice cultivation has shown significantly difference from other establishment methods and had experienced highest amount ($P < 0.05$) of rice thrips, leaf folder and paddy bug incidence in three cultivation seasons within the studied period. But, there was no any considerable variation of temperature (26.4-30.5 °C), relative humidity (64.3-70.9 %) and yield (11-12 kg) among four different crop establishment methods in each cultivation season.

Keywords: Cultivation seasons, Pest abundance, Plant establishment methods, Rice

In-Vitro Antibacterial Activity and Preliminary Phytochemical Analysis of Locally Available Green Leafy Vegetables

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Green Leafy Vegetables (GLVs) are a rich source of nutrition and contains medicinal values. This study was carried out to investigate the phytochemical properties and antibacterial activities of three locally available GLVs, namely *Argyreia pomacea, Coccinia grandis and Mollugo pentaphylla*. All leaf samples were collected from the public market, Batticaloa, Sri Lanka. The phytochemical analysis was determined by the standard qualitative method described by Trease and Evans. The antibacterial activity against *Escherichia coli* and *Staphylococcus aureus* was tested for the leaf extracts from acetone and ethanol at 25, 50 and 75 mg/100 µL using well diffusion method. Both pure cultures were obtained from Microbiology laboratory, Teaching hospital, Batticaloa. Eighteen nutrient agar petri dishes were prepared for three different type of leaf extracts of each solvent and bacterium. Totally 72 media plates were prepared and repeated 6 times. Bacterial suspension (1×10^6 cells/mL) were taken from serial dilution and wells with 8 mm diameter were filled with 100 µL of each concentration of extracts. Streptomycin used as positive and each extracts were used as negative control. The antibacterial activity was determined by measuring the diameter of clear inhibition zone around the well. The highest inhibitory effect on *E. coli* and *S. aureus* was shown by ethanol extract of all samples. The ethanolic extract of *C. grandis* showed better antibacterial activity against *S.aureus* (22.7 ± 0.5 mm) and *E. coli* showed highest susceptibility to *C. grandis* (20 ± 0.6 mm) in ethanol extract at 75 mg/100 µL. The inhibitory effect was observed at all concentrations of acetone and ethanol extracts of *C. grandis* against both bacteria. Also, the phytochemicals such as alkaloids, saponins, flavonoids and tannins were found in both extracts of *C. grandis.* Saponins and tannins were found in both extracts of all three leaf types, tested. Flavonoids were found in the ethanol extracts of *A. pomacea, and M. pentaphylla*. Thus, GLVs could be considered for finding bioactive natural products, used to produce some pharmaceuticals drugs to cure different diseases.

Keywords: Antibacterial activity, *Escherichia coli*, Green leafy vegetables (GLVs), Phytochemicals, *Staphylococcus aureus*

Screening of Sugarcane Germplasm and Quarantine Station for Sugarcane Streak Mosaic Virus in Sri Lanka

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Sugarcane streak mosaic virus (SCSMV; Genus *Poacevirus,* Family; Potyviridae) is a new virus caused sugarcane streak mosaic diseases in Sri Lanka. Recently, mosaic-like symptoms were observed in *Saccharum* germplasm at Enselwatta and sugarcane accessions in sugarcane quarantine station Hanthana, Sri Lanka. Identification of disease states in *Saccharum* germplasm is important because there is a possibility to transmit systemic disease through true-seeds. Therefore, this study was carried out to identify the sugarcane accessions infected with SCSMV in *Saccharum* germplasm at Enselwatte and the sugarcane varieties are being quarantined at Hanthana after importation. Hundred and fifty sugarcane leaf samples exhibiting sugarcane streak mosaic symptoms were subjected representatively and randomly form every block (10 % from total accessions) and locally bred varieties from sugarcane germplasm collection at Enaselwatta, Deniyaya and quarantine station Oduwila, Hanthana to this study. Tissue cultured virus eliminated sample was used as a control sample. Total RNA was extracted from individual leaf samples using size fractionate silica based method. Two steps Reverse Transcription-PCR (RT-PCR) was carried out using most common SCSMV coat protein specific primer pair cpF (5'-GTG GGT TCA GTT CTC GGT TC-3') and AP3 (5'-TTT TTT CCT CCT CAC GGG GCA GGT TGA TTG-3') which amplify 500 bp DNA fragment of partial coat protein gene (CP) and the 3' terminal of SCSMV. Presence or absence of the disease was confirmed by the band visualized in 500 bp region in agarose gel electrophoresis. The molecular detection results of this study concluded that the virus has infected in *Saccharum* germplasm and sugarcane quarantine station indicating 91 % of tested accessions/varieties. The *Saccharum* germplasm should be re-established with SCSMV free material produced from virus elimination process, precautions to be taken during genetic material exchange and resistant varieties should be developed for SCSMV.

Keywords: *Saccharum,* Germplasm, Sugarcane, SCSMV, Revers transcription-PCR

Soil Science, Plant Nutrition, Nutrition, Food Science and Technology

Estimated Daily Intake and Health Risk of Heavy Metals by Consumption of Nutrient Rich Cyanobacteria Strains Isolated From Different Fresh Water Bodies of Sri Lanka

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Cyanobacteria produce a wealth of high-value bio products and have been mass cultivated for centuries as a nutritional supplement. Today there are numerous commercial applications of cyanobacteria as they can be used to enhance the nutritional value of food and animal feed owing to their chemical composition. Heavy metal toxicity is a major threat and health risk of cyanobacteria. This study was carried out to analyze the heavy metals of nutrient rich cyanobacteria isolated from different fresh water bodies of Sri Lanka. Cyanobacteria containing water samples were collected from ten different water bodies, representing three climatic zones *i.e.,* Dry zone (Ariyakulam, Nelumwewa, Muthuvinayakasam, Kannaththiddikulam, Balaluwewa, Ibbankatuwa), Intermediate zone (Kurunegala, Kandy), Wet zone (Ambewela, Gregory). Samples were cultured in specific media (BG-11 and GO) and eleven uni-algal cultures (nutrient rich) were isolated by repeated sub culturing. The cyanobacteria were identified morphologically as *Phormidium* sp., *Cephalothrix komarekiana, Chroococcales* sp., *Planktolyngbia* sp., *Cephalothrix* sp., *Microcoleus* sp., *Oscillatoria* sp., *Mycrocystis* sp., *Synechococcus* sp., *Pseudaanabaena* sp., and *Dermocarpa* sp. Each cyanobacteria strain was tested against eight different heavy metals (Cd, Ni, Cr, Pb, Co, Cu, As, Fe) using ICP-OES machine. Cu and Co were present in significantly higher amounts compared to other elements. *Cephalothrix komarekiana* and *Dermocarpa* sp. had significantly higher amounts of Cu (70.2 µg/kg and 50.6 µg/kg, respectively) than the other species. *Cephalothrix komarekiana* and *Chroococcales* sp. had higher amounts of Co (24.0 µg/kg and 19.5 µg/kg, respectively). *Dermocarpa* sp. and *Cephalothrix komarekiana* had higherst amounts of Cr (3.0 µg/kg ad 2.6 µg/kg, respectively). Fe and Ni were present in considerable amounts in all the tested cyanobacteria strains. Heavy metals Cu and Co had exceeded the Estimated Daily Intake (EDI). Metals Cd, Pb and As were present in comparatively lower quantities in in all the tested strains. The results suggested that tested heavy metals from cyanobacteria might involve in health related risks to the consumers.

Keywords: Estimated daily intake, Health risk, Heavy metals, Toxicity

Performance of Plant Growth Promoting Rhizobacteria on Cluster Onion (*Allium cepa* L.) Under Field Condition

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A field experiment was conducted to evaluate the performance of previously screened plant growth promoting rhizobacteria on growth and yield of cluster onion (*Vethalam*). Five bacterial strains (AZO-1, AZO-3, AZO-5, AZO-6, and AJ4) which were isolated from onion rhizosphere in dry zone having the ability to fix nitrogen and solubilize phosphorus were used. These were tested along with organic fertilizer (cattle manure) and in combination with inorganic fertilizer. Field experiment was conducted in Regional Agricultural Research and Development Centre, Kilinochchi during *Maha* season 2018 and designed in Randomized Complete Block Design with triplicates. There were twelve treatments; T_1 (Control), T_2 (AZO-1), T_3 (AZO-3), T_4 (AZO-5), T_5 (AZO-6), T_6 (AJ4), T_7 (Recommended NPK), T_8 (1/3RNP + AZO-1), T_9 (1/3RNP + AZO-3), T_{10} (1/3RNP + AZO-5), T_{11} (1/3RNP + AZO-6) and T_{12} (1/3RNP + AJ4). Onion bulbs were inoculated with respective strains ten minutes prior to planting. Data regarding growth, available nutrients and yield parameters including bulb length, bulb diameter and yield were recorded during the experiment and analyzed by using statistical package (SAS 9.1). The highest height (21.627 cm) and total leaf number per plant (18) were recorded in T_{11} (1/3RNP + AZO-6) and highest bulb length (4.93 cm) and bulb diameter (2.973 cm) were noted in T_{12} (1/3RNP + AJ4). Nutrient availability in rhizosphere soil at 45 days after planting, available nitrogen was highest (2.24 mg/100 g) in T_8 (1/3RNP + AZO-1) and there was no significant difference between T_8 (1/3RNP + AZO-1), T_6 (AJ4), T_{11} (1/3RNP + AZO-6) and T_{12} (1/3RNP + AJ4). Significantly higher available P was observed in T_3 (AZO-3) and T_5 (AZO-6). Available K was highest (39.82 ppm) in 1/3RNP + AZO-6 (T_{11}) and lowest (15.49 ppm) in AZO-1 (T_2). All the inoculated plants showed significantly (*P=0.05*) higher yield compared with control except T_9 (1/3RNP + AZO-3) and T_3 (AZO-3) and comparable to recommended fertilizer. Yield (8.586 t/ha) was obtained in T_{11} (1/3RNP + AZO-6) and it was followed by T_{12} (1/3RNP + AJ4). Therefore, present study concludes that the strains AZO-6 and AJ4 with organic fertilizer have the potential to improve onion growth and yield with or without inorganic fertilizer under field conditions. It is suggested that further field experiments under various agro ecological region is necessary to confirm the performance of selected strains.

Keywords: Available nutrients, Bacterial strains, Onion, Yield

Exploring Nitrogen Uptake, Utilisation and Use Efficiency of Different Wheat Species

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One of the many challenges faced by wheat breeders is narrowed genetic diversity of existing bread wheat cultivars due to selective breeding for high yield. The present study was carried out to investigate the nitrogen use efficiency of ancient wheat species, a potential source to expand the genetic diversity of modern bread wheat. Two field experiments were carried out in 2013 and 2014 at Sutton Bonington Campus, University of Nottingham, UK. Split-plot design was used in both experiments where N treatment was randomised on main plot and genotypes on the sub-plot with three replicates. Ten genotypes belong to Einkorn, Emmer, Spelt and modern bread wheat were used. Three N regimes equal to zero N (no fertiliser N applied), 100 kg N ha^{-1} and 200 kg N ha^{-1} were used in 2013 while zero N, 100 kg N ha^{-1} and 150 kg N ha^{-1} was applied in 2014. Soil type of the experiment site was sandy loamy. Plant N uptake (N*off*; excluding roots), N uptake efficiency (NUpE), N utilisation efficiency (NUtE) and NUE were calculated at harvest. N*off* differed significantly between genotypes ($P < 0.05$) and N treatment ($P < 0.001$) while spelt and emmer had the most N*off* in both experiments. Similarly, NUpE was also high in spelt and varied significantly between genotypes ($P < 0.001$ in 2013; $P < 0.05$ in 2014) and N levels ($P < 0.01$ in 2013; $P < 0.001$ in 2014). However, NUtE was greater in modern bread wheat in both experiments resulting high NUE. The interaction between genotype and N level was significant ($P < 0.001$) for NUtE in both experiments. According to the results, it can be concluded that ancient wheat genotypes have an ability to uptake more nitrogen hence high NUpE when compared to modern bread wheat. However, modern bread wheat perform well for NUtE and NUE due to high harvest index.

Keywords: Efficiency, Nitrogen uptake, Utilisation, Wheat species

The Potential Use of Cyanobacteria as Biofertilizer for Rice Variety BG-251

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A study was conducted to assess the potential use of selected cyanobacteria namely *Limnothrix* sp., *Anabaena* sp., *Chroococcidiopsis* sp. and *Calothrix* sp.on growth and yield of rice varierty BG-251. A pot experiment was conducted for paddy with selected cyanobacteria strains with 12 treatments which were T_1- *Limnothrix* sp. + TSP + MOP, T_2- *Anabaena* sp. + TSP + MOP, T_3- *Chroococcidiopsis* sp.+ TSP + MOP, T_4- *Calothrix* sp. + TSP + MOP, T_5- *Limnothrix* sp. + *Anabaena* sp. + TSP + MOP, T_6-*Limnothrix* sp. + *Chroococcidiopsis* sp. TSP + MOP, T_7-*Limnothrix* sp. + *Calothrix* sp. + TSP + MOP, T_8-*Anabaena* sp. + *Chroococcidiopsis* sp.+ TSP + MOP, T9-*Anabaena* sp.+*Calothrix* sp.+TSP+MOP, T_{10}- *Chroococcidiopsis* sp. + *Calothrix* sp. + TSP + MOP, T_{11}- Department recommended fertilizers and T_{12}- Control. For treatments with cyanobacteria no any nitrogen fertilizers were applied while triple super phosphate and murrate of potash were applied. Cyanobacteria was applied as fresh biomass. Plant height, shoot dry weight, root dry weight, nitrogen, phosphorus and potassium uptake and yield were measured after 75 days of planting. Experiments were designed as completely randomized design with twelve treatments in three replicates and the data were analyzed by using SAS 9.1. Significant variations between the treatments were evaluated by Duncan's Multiple Range Test. The results showed comparable plant height in all cyanobacteria treatments with Department recommended fertilizers. The highest shoot weight (0.316 g/plant) was recorded in treatment with combination of *Anabaena* sp. and *Chroococcidiopsis* sp. on 45th day and the highest root weight (1.085 g/plant) was found in treatment with combination of *Limnothrix* sp. and *Anabaena* sp. Treatments with selected cyanobacteria showed equal or higher nitrogen, phosphorus and potassium uptake compared with recommended fertilizers. Nutrient uptake was positively correlated with plant dry biomass. The grain yield was highest (0.928 g/plant) in treatment with combination of *Limnothrix* sp. and *Calothrix* sp. However, it was not significantly different from all other treatments except treatment with *Calothrix* sp. alone or control. Results therefore indicate the potential of using the studied cyanobacteria in bio-fertilization for paddy in flooded condition.

Keywords: Bio fertilizer, Cyanobacteria, Rice field

Development of Cinnamon Biscuits with No Added Sugar and Evaluation of Its Quality Characteristics

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The aim of the current research was to develop cinnamon biscuits with no added sugar and evaluation of its quality characteristics. In this study, biscuits were developed by fully replacing sugar with different amount of cinnamon powder (5, 10 and 15 %) and biscuits with recommended level of sugar was used as a control. Sensory evaluation test with 5 point hedonic scale with thirty panelists was performed to select the best sample among the different treatments. Based on the sensory evaluation test most of the panelist preferred, biscuits fortified with 15 % cinnamon powder and it was selected for further analysis along with control. Total nitrogen content of the selected samples were estimated by Kjeldhal method and the total nitrogen content of sensorially accepted biscuit was lower than control (0.65 %). Therefore egg albumin was added to developed biscuits to improve the nitrogen content. After improvements total nitrogen content was increased up to 1.02 % and as well as physical and sensory properties were higher than control sample. The microbiological quality of the developed biscuits were tested with total plate count and yeast and mould count. The microbiological quality of the samples were acceptable according to SLS standard up to 3 months of storage period. There is no significant difference in the cost of production of control and the most accepted cinnamon biscuits, which were LKR. 140/12 biscuits and LKR. 142/12 biscuits respectively. It could be concluded that biscuits with 15 % cinnamon powder has a potential for commercialization and further studies with large scale is needed for its conformation.

Keywords: Biscuits, Cinnamon, Sensory evaluation

Determination of Heavy Metal Contamination of Economical Important Food Commodities

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This study was conducted to evaluate the presence of heavy metals (Arsenic (As), Cadmium (Cd), Lead (Pb), Copper (Cu)) in economically important seven food commodities such as red onion, B onion, chilli, potato, apple, orange and grapes. Five hundred samples from both local and imported food commodities were randomly collected, and analyzed for the presence of heavy metals following standard methods of AOAC 999.10 and AOAC 986. 15–17th edition. Heavy metal contaminations of these local and imported samples were compared with recommended maximum safe levels (WHO/FAO standards, As = 0.1, Cd = 0.2, Pb = 0.3 and Cu = 40 ppm) and area wise comparison was carried out for local samples. According to the acceptable levels mean values of As, Pb and Cu in local food commodities were below the maximum safe levels. One sample t- test was used to analyze the data. The mean value of Cd content in potato samples (0.2436 ± 0.74 ppm) had significantly ($P < 0.05$) exceeded the maximum safe level (MSL), while other commodities had not exceeded the consumer safety level of Cd. In imported food commodities, the values of As, Pb and Cu were below the MSL. The mean value of Cd content in potato (1.134 ± 2.68 ppm) and apple (1.075 ± 4.138 ppm) were exceeded the MSL significantly, while red onion, B onion, chilli, orange and grapes commodities had not exceeded the MSL of Cd. Pb concentration was high in Bibila and Amparaorange samples. Pb and Cd levels were high in red onion samples collected from Jaffna. High concentration of Cd was reported in B onion collected from Dambulla. Nuwara Eliya reported high concentrations of As, Cd and Pb in apple, potato and orange while high concentrations of As, Cd and Pb were reported in apple, grapes and orange for samples collected from Pettah. The results revealed that some commodities have exceeded the MSL for Cd, As and Pb in both imported and local samples and further analysis should be carried out in the areas where high heavy metal contaminants were reported.

Keywords: Consumer safety, Economically important food, Heavy metal

Analysis of Antimicrobial Effect of Cinnamon and Nutmeg Oil Extractions on Preserving Tomato Sauce

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Cinnamon and nutmeg essential oils are considered to have high antimicrobial potential that will be beneficial as natural food preservatives. Sodium benzoate is a common preservative used but reveals to have many negative health effects. Hence this research attempts to evaluate the potential of preserving tomato sauce based on the antimicrobial effect of cinnamon and nutmeg essential oil extractions. Freshly prepared tomato sauce samples were separately treated with 0.05, 0.1, 1.0 and 2.0 % concentrations of cinnamon bark oils (70 % cinnamaldehyde and 40 % cinnamaldehyde containing samples), cinnamon leaf oil and nutmeg seed oil. 0.05 % concentration of cinnamon bark oils, cinnamon leaf oil and nutmeg seed oil showed best sensory properties in the tomato sauce. Cinnamon leaf oil treated sample was rejected from the sensory analysis and most preferred sample was nutmeg seed oil treated sample and there were significant difference in taste and aroma compared to other samples. pH, brix and total titratable acidity analysis and microbial analysis were carried out for 0.05 % spice oil treated tomato sauce samples at initial stage and after 6 weeks storage at room temperature and refrigerated temperature. According to the results pH, brix and total titratable acidity values were 3.63 ± 0.02 - 3.85 ± 0.01, 41.7 ± 0.1 - 43.7 ± 0.12, 1.74 ± 0.06 – 1.88 ± 0.04 (as acetic acid, percent by mass) respectively. Total plate counts (SLS 516-1-Sec, 1:2013) were $< 1.4 \times 10^2$ cfu/g at initial stage, $< 1.364 \times 10^3$ cfu/g after 6 weeks stored at room temperature and $< 6.82 \times 10^2$ cfu/g after 6 weeks stored at refrigerated temperature (4°C - 8 °C) for all samples and yeast and mold count (SLS 516-2-Sec, 1: 2013) were not detected in all samples. According to the results, there is a possibility in using cinnamon bark oil and nutmeg seed oil in preserving tomato sauce based on pH, brix, total titratable acidity and total plate count according to SLS 260:1989 standard.

Keywords: Antimicrobial effect, Cinnamon oil, Natural preservative, Nutmeg oil, Tomato sauce

Study of Probiotic Activity of Selected Sri Lankan Traditional Rice Varieties when Inoculated by *Lactobacillus plantarum*

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This study was conducted to investigate the prebiotic potential of selected traditional rice varieties by inoculating with probiotic bacterium, *Lactobacillus plantarum.* Five traditional rice varieties; *Suwandel, Pachchaperumal, Kaluheenati, Kurulu thuda* and *Madathawalu* as treatments and BG-358 rice variety as control were used in flour form. Dietary fiber and resistant starch content of selected varieties were measured according to AOAC method 2009.01, 2011.25 & 2002.02. Culture media was modified by combining MRS agar with rice flour in 4:1 ratio. *L. plantarum* was inoculated while inhibiting the growth of other bacterial species using ciprofloxacin. Colony Forming Units (CFU) of *L. plantarum* were calculated and it is significantly ($P < 0.05$) higher in all traditional varieties compared to the control variety. CFU varied from $1.87 \pm 0.04 \times 10^7$ to $2.58 \pm 0.05 \times 10^7$ and highest CFU was reported in *Kaluheenati* variety ($2.58 \pm 0.05 \times 10^7$). Prebiotic activity score was calculated by inoculating *L. plantarum* as the probiotic and *Escherichia coli* as the enteric bacteria. Prebiotic activity score was varied from 1.23 ± 0.01 to 1.46 ± 0.02 and *Kaluheenati* expressed significantly higher score than the other traditional varieties. *Kaluheenati* rice variety possesses significantly ($P < 0.05$) higher values of dietary fiber (6.97 ± 0.03 %) and resistant starch (2.53 ± 0.02 %) than the other tested rice varieties. The results revealed that *Kaluheenati* variety has the highest dietary fiber and resistant starch content which is considered to be good for diabetes mellitus type 2. The highest prebiotic activity score of *Kaluheenati* reflects that this variety has appreciable prebiotic potential compared to the other varieties hence enhances the digestive health of the consumers.

Keywords: Dietary fiber, Prebiotics, Probiotics, Resistant starch, Traditional rice

Identification of Potential Treatments to Overcome the Browning of Dehydrated Guava

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Guava cultivations are spreading rapidly among Sri Lankan farmers, especially in dry zone. Surplus production is observed in certain months of the year. Dehydration can be used as an effective method to preserve the surplus. On dehydration, browning of guava cultivar "Apple guava" impairs the quality of the final product. Hence, this experiment was carried out to find out the most effective browning inhibitor. Four treatments were used, prior to dehydration, namely, Citric acid (CA), Ascorbic acid (AA), Sodium metabisulfite (SMS) and Blanching for 2 minute in 60 °C (BL). Out of twenty different combinations of the above treatments, five treatment combinations were selected for further evaluations. Selected treatment combinations were: CA 0.3 % with BL, CA 0.5 % with BL, AA 0.5 % with BL, SMS 0.5 % with BL and only BL. The L*, a* and b* values, signifying colour parameters, were recorded and colour differences with the fresh slices were calculated. Values were compared among treatments, the control being the dehydrated sample without treatment and with fresh samples as well. The L*, a* and b* values were significantly different ($P < 0.05$) among treatments. Highest L* was observed in fresh sample (85.74 ± 1.3) whereas lowest was in the control sample (67.91 ± 4.1). Significant difference ($P < 0.05$) was observed in L* value difference (LD) with respect to fresh samples among the treatments. The lowest LD was observed in CA 0.3 % with BL (3.18 ± 0.7) followed by BL treatment only (4.37 ± 2.7) whereas highest was observed in control sample (18.23 ± 2.7). Lowest a* value was observed in fresh samples whereas highest was in AA 0.5 % with BL. Lowest difference in a* value was in BL treatment followed by CA 0.3 % with BL. Lowest b* value was observed in fresh samples whereas highest in SMS 0.5 % treated sample with BL. Lowest difference in b* value was in BL treatment. Results revealed that out of the treatments under study, BL only and CA 0.3 % with BL were most effective solutions to overcome the browning of dehydrated guava.

Keywords: Browning, Colour, Guava, Postharvest

Utilization of Mangosteen (*Garcinia mangostana* L.) Peel Powder Extract for the Production of Functional Stirred Yoghurt

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Mangosteen (*Garcinia mangostana* L.) peel powder (MPP) extract was incorporated to develop stirred yoghurt rich in functional properties. Mangosteen peels are seasonal agricultural waste, rich in phenolic compounds and antioxidant activity. Ethanol (80 %) with MPP (10:1) extract was prepared. Stirred yoghurt was produced using pasteurized cows' milk (3.25 % fat, 23 % total solids) incorporating 1.0, 1.5 and 2.0 ml of MPP extract/kg of yoghurt mixture as treatments. Sensory evaluation in nine point hedonic scale was conducted to determine the best level of MPP extract that suit for the best sensory attributes in stirred yoghurt. The control was prepared without MPP extract. Total phenolic content (TPC) and antioxidant activity [DPPH radical scavenging activity (RSA %)] of MPP extract and the treatments were determined using the standard procedures. pH profile during storage of yoghurt was recorded. Physico-chemical analysis and microbiological parameters were determined. Sensory evaluation was conducted using nine point hedonic scale and data was analyzed by Kruskal-Walls test, non parametric one-way ANOVA test at $P < 0.05$. Among all treatments MPP extract treated (1.5 mL/kg) yoghurt was selected as the best. Total phenolic content (mgGAE/g) of MPP, best treatment and control were showed 115.10 ± 0.05, 3.88 ± 0.14 and 2.5 ± 0.04 respectively. Antioxidant activity (RSA %) in MPP extract was 57.81 ± 6.56 % while in treated yoghurt was not detected. Results revealed that organoleptically acceptable, microbiologically safe stirred yoghurt rich in functional properties could be developed by incorporating MPP extract at 1.5 mL/kg yoghurt. pH reduction was significantly higher ($P < 0.05$) in best treatment compare to the control samples. Acceptability of the best selected sample was lower than the control due to the presence of noticeable aftertaste. The best selected yoghurt with MPP extract 1.5 mL/kg has possessed 26 days of shelf life compared to the control (24 days) at 4 ± 1 °C without adding preservatives.

Keywords*:* Mangosteen peel powder extract, Stirred yoghurt, Total phenolic content

Nutritional Composition and Antioxidant Activity of Selected Seaweeds from Northern Region of Sri Lanka

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The aim of this study was to investigate the nutritional composition and antioxidant activity of methanolic extracts of brown seaweed, *Turbinaria ornata* and *Sargassum polycystum* and green seaweed *Caulerpa racemosa*. Samples of *T. ornata* and *S. polycystum* were collected from the Naachikuda coastal area while *Caulerpa racemosa* was collected from the Keerimalai coastal area in the Northern region of Sri Lanka. Collected samples were dried under shade condition until reach a constant moisture level and powdered and kept in airtight containers. These samples were used to determine nutritional composition and antioxidant activity. Crude protein, crude fat, crude fiber, carbohydrate, ash and moisture content of the selected species were analyzed in determining the nutritional composition. Among the three selected species, *C. racemosa* contained the highest ($P < 0.05$) amount of crude protein, moisture, crude fat and ash content, while *T. ornata* and *S. polycystum* had the highest ($P < 0.05$) carbohydrate and crude fiber content, respectively. Methanolic extracts of seaweeds were used to determine the antioxidant properties such as total phenolic content, (expressed as Gallic Acid Equivalent (GAE), total flavonoid content (expressed as Catechin Equivalent (CAE), total antioxidant capacity (expressed as Ascorbic Acid Equivalent (AAE) and DPPH radical scavenging activity (expressed as IC_{50}). Among the three selected species, *T. ornata* had the highest ($P < 0.05$) total phenolic content (0.74 mg GAE/g dry seaweed), total flavonoid content (0.50 mg CAE/dry seaweed), total antioxidant capacity (4.49 ± 0.35 mg AAE/g dry seaweed) and DPPH radical scavenging activity (IC_{50}=0.52 ± 0.01) followed by other two seaweeds with potent antioxidant properties. Findings of this study showed that all the studied seaweeds are rich source of antioxidants and nutrients. Thus, these seaweeds could be used as a potential source for developing nutritional and functional foods.

Keywords: Antioxidant, Seaweed, Nutritional components

Physical and Chemical Quality of Locally Available Bottled Water in Batticaloa District, Sri Lanka

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The quality of drinking water during recent years has been deteriorated considerably due to several factors, particularly, the presence of toxic elements, which even in trace amounts could cause serious health problems. This study was aimed to determine the physical and chemical quality of bottled water, available in the local retail outlets in Batticaloa district, Sri Lanka. Twenty different brands of bottled water were purchased from retail outlets in Batticaloa district. Three bottles of each bottled water brand were purchased at different retail shops. To keep the brand names anonymous, bottled water samples were given alphabetical code from A to T and this convention used throughout the text. Some parameters such as colour, pH, Electric conductivity, Turbidity, Nitrate, Fluoride, Chloride, Phosphate, Total hardness, Iron. Na and K determination were carried out in the Laboratory. Electric conductivity (EC) value was ranged from 7.79 - 236 µS/cm. and were lower than recommended level (750 µS/cm). The pH of 15 brands of bottled water were within the limit, recommended by the World Health Organization (WHO) (6.5-8.5), rest of five brands were varied. (4.97-6.40). The total hardness was from 0.4 - 5.2 mg/L for three brands, out of 20 different brands of bottled water, tested. The permissible level of total hardness by WHO is 250 mg/L. The chloride values varied from 1.06-1.9 mg/L for five brands, whereas the acceptable level of chloride by WHO is 250 mg/L, which shows the concentrations of minerals were lower than the recommended level by WHO. However, colour, turbidity, nitrate, fluoride, phosphate, iron, total dissolved solids, sodium and the potassium level were within the limits of Sri Lankan Standard (SLS) and WHO. Hence, it can be concluded that the water samples less satisfactory for drinking purpose. Because of the less amount of mineral constituents and pH variation from the WHO and SLS permissible limits. And there is no assurance that since water comes out of a bottle does not mean it is free from contamination. There are varieties of bottled water and their quality also varies. Thus it is necessary to pick up the right brand, stricter rules should be made and implemented to regularly monitor the bottled water qualities.

Keywords: Bottled drinking water, Physiochemical parameters, World Health Organization

Post-Harvest Technology, Farm Mechanization and Waste Management

Sri Lankan Consumers Perception towards Disposal of Plastic Beverage Bottles in Colombo District

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Waste management is a burning problem, mostly in urban areas. Waste could be categorized into different types based on their characteristics. The major problem in garbage is lack of proper disposal. Authors have identified this problem as hands on experience with Zerotrash initiative. This leads to signify the essentiality of such research on consumer perception on waste disposal. This study was focused mainly on to Colombo district due to time limitation. The major objective of the research is to identify the perception of consumers on disposal of plastic bottles. The specific objectives of the study are to; identify the consumer awareness level on different types of plastic, identify the consumer readiness level to go for extra mile in separating plastic bottles based on the type and to provide recommendations to enhance the proper disposal of plastic wastes in Sri Lanka. The data were collected via a questionnaire survey, first person observation and semi structured interviews with experts. Questionnaire survey data were quantitatively analyzed in Likert scale. The convenient sampling method used for questionnaire survey with sample size of 260 covering each DS division. 09 experts were reached based on snowball sampling for the structured interview. The majority of the respondents do not have a proper channel to dispose garbage since lack of availability and contacts of recyclers. Urban Councils reject some types of garbage resting households to burn them. Lack of awareness on type of plastic is one major reason for improper dumping of garbage, resulting recyclers to add additional cost for plastic separation based on the category. Less awareness on proper steps to follow in plastic disposal is also one of the major reasons which create hard time for recyclers and handlers. The finding leads to three conclusions as; community awareness on plastic disposal methods should be enhances through more education programmes, the gap between recycler and households is yet to be filled, community does not have clear idea about their role in plastic recycling. The recommendations were made in three areas, consumer education, public relation and community empowerment and, technology application.

Keywords: Consumer perception, Plastic waste, Segregation, Waste disposal

Development of a Portable, Height Adjustable and Safe Smoker for Chasing Giant Honeybees (*Apis dorsata*)

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Giant honeybee (*A. dorsata*), called *Bambara* in Sinhala has been pervaded all over the Sri Lanka. It lives in a colony of a large single vertical comb, which is built in the open and fixed underneath of rock cliffs, branch of a tree and eaves of building, overhead water tanks and towers at height up to 50 meters. Although, naturally they show aggressive behaviour, they are considered to be the most important pollinator of the nature. Tourist, pilgrims, tea pluckers and school children are often the victims of *bambara* attacks. As a solution, colony is dispelled by using various harmful methods including burning. Use of smoke towards the colony and then removal of the comb is a suitable technique to dislocate them. However, a safe and reliable mechanical smoking device is not available. Therefore, this study aimed to introduce a portable, height adjustable and safe smoker for chasing giant honeybees. Smoker consists with smoke generation unit, smoke blowing unit, power supply unit and smoke delivery unit. The volume of the smoke generation unit is 4 L and the height of the delivery unit can be adjusted within 10 m. Straw and Guinea grass (1:1 ratio) were used as the firing material and performance of the smoker was tested with different compaction levels. Firing time, air flow rate and temperature of smoke were measured during each trial. Data were analysed by ANOVA using Complete Randomized Design. The suitable compaction level for the smoke generation unit was, when it filled with 270 g of mixture. Firing time, smoke flow rate and the temperature of smoke at this level were recorded as 21 minutes, 18.5 L/min and 37 ^{0}C respectively. It took only 8 minutes to chase giant honeybees from a colony. According to the performance, the newly developed smoker could be recommended for chasing *Bambara* colonies effectively and safely.

Keywords: Chasing, Giant honey bee, Parts of the smoker, Performance of the smoker

Testing and Evaluation of the Chimney Type Solar Dryer (CTSD) for Cottage Industries in North

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Food technology in Sri Lanka is a desired need of significant development to make value added product of a wide variety of both fruit and vegetables. There is a massive surplus production during the season. However, it is perishable in nature. Therefore, proper post harvest handling and preservation are essential. Fruits and vegetables are highly profitable commodities for both small-scale and large-scale farmers. Unfortunately, fresh produce is very perishable and postharvest losses can be quite high. Hence, researches have been initiated in the dehydration of vegetables. The newly designed solar drier with heated air circulation focuses the method of improvement in moisture removal and cost reduction. The dryer comprises of a long table covered with black plastic, which is connected to a chimney at one end. The principle of the solar chimney effect is a combination of solar stack-assisted and wind-driven ventilation. The use of the solar energy is getting a greater importance in the agriculture as because of the growing energy prices and the importance of the environment protection. Solar driers can generate higher air temperatures and lower relative humidity. Initially the rate of moisture removal (g/min) was high, which gradually it was decreased none linearly. Drying process was analyzed by the regression value in the model of moisture removal rate (gram of water per minute) and temperature gradient in ^{O}C (ambient – inside temperature) for different produces like lime and chilli, which are high and low range (80 & 60 %) moisture vegetables. Comparative study was performed in open space sun drying. The regression model can be used for the prediction of drying efficiency explained by regression value and duration at particular temperature gradient. Best-fitted exponential model for moisture removal rate was obtained in two extreme moisture conditions by the equation of $0.024\ e^{0.0521x}$ for lime with the regression value of 0.9668 and $0.015\ e^{0.0778x}$ with the regression value of 0.9726 for chilli respectively. Chimney Type Solar Dryer (CTSD) design was performed at high efficiency compared to open sun drying.

Keywords: Chimney solar dryer, Design, Dryer, Fabrication

Effects of Effluent Changing Interval on Milling Yield, Hydration Profile, Physical Properties and Effluent Characteristics of Two Different Rice Varieties

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Parboiling is the hydrothermal treatment applied to the paddy grains before milling in order to increase the milling recovery. Parboiling process consist of three stages such as soaking, steaming and drying. In this study, the effects of effluent changing interval on milling yield of two different paddy varieties were estimated. In addition, the characteristics of effluent and hydro profile of paddy also were evaluated. Paddy varieties of BG 360 and *Addakari* were soaked in water at ambient temperature. Two experimental setups were designed as first setup designed for both varieties with changing the effluent at each 12 hours interval and second for at 24 hours interval within 48 hours duration. At every 6 hours interval, effluent samples were collected for characterization. After 48 hours of soaking, paddy grains were steamed till few of their hulls split off. It was then cooled and sun dried until the moisture reduced up to 14 %. Analytical grade de-husking and polishing machines were used for the milling. In the milling yield analysis, *Addakari* rice variety with changing the effluent at 12 hours interval resulted in higher brown rice percentage, total milled rice percentage and degree of milling percentage as 81.77, 73.66 and 90.08 % respectively. The higher head rice percentage was 68.26 % to the same variety but with changing the effluent at 24 hours interval. The rice variety BG 360 with effluent changed at 24 hours interval yielded higher hull percentage as 21.66 %. The whiteness value of BG 360 with changing the effluent at 12 hours interval was higher than other treatment and that of other variety as 27.8 %. Due to the larger surface area of BG 360 rice variety, it resulted in higher hydration profile. When considering the effluent characteristic with different changing interval of effluent, the treatment with time interval of 12 hours showed lesser level contaminants in the effluent, which can be utilized for the secondary purposes like irrigation. According to this study, it was identified that effluent changing interval, influences the milling yield, hydration profile and physical properties of different rice varieties.

Keywords: Drying, Effluent, Head rice percentage, Milling yield, Parboiling, Soaking

Testing and Evaluation of Double Layer Evaporative Cooler for Vegetables Preservation

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Agriculture is a major part of income in Sri Lanka. In whole country is facing a problematic issue on preservation agriculture produce. There are many factors cause in post-harvest losses. To minimize such losses proper post-harvesting practices, should be maintained. Introduction of cost effective method for storage of vegetables is necessary to maintain freshness until produce reaches the destination market. The double layer cool chambers were designed and tested for cooling effectiveness separately using clay bricks, anthill clay, sawdust and charcoal. The sawdust and charcoal zero energy double layer cool chambers were made to develop suitable conditions for storage, enhance the time duration and minimize the weight loss of vegetables. The evaporative cooling principle was followed under cooling chamber system. Saw dust and charcoal were filled separately in to the layers and saturated with water circulated from top to bottom. Temperature and relative humidity inside and outside of chamber were measured in hourly intervals in day time. The samples of *Amaranthus* spp., brinjal and carrot were selected for evaluation and placed inside the cool chambers, with wrapped and unwrapped conditions. Weight loss was measured at hourly intervals to check the effectiveness of the design. Physiological weight loss for all selected vegetables was low for samples placed charcoal media cool-chamber than the sawdust media cool-chamber than outside. For the testing of cooler design the regression analysis was implied to fit the relationship between log mean temperature ratio against time duration of cooling in sawdust media cool-chamber and charcoal-media cool-chamber. The cooling rate (CR) was expressed by slope of the equation respectively. The regression vale was explained the efficiency of cooling. The relationship derived to charcoal media cool-chamber was $y = -0.015x + 0.063$ with regression value of 0.978 and saw dust media cool-chamber $y = -0.033x + 0.079$ with regression value of 0.856. The cooling rate and efficiency of cooling was high in charcoal as filling media within double layer coolers. Since the regression value was more than 80 %, in the both design-cooling rate and efficiency of cooling was highly satisfied. Charcoal chamber and sawdust cool-chamber are satisfied the requirement of evaporative cooler.

Keywords: Double layer cool chamber, Evaporative cooler, Zero energy cooler

Irrigation and Water Management

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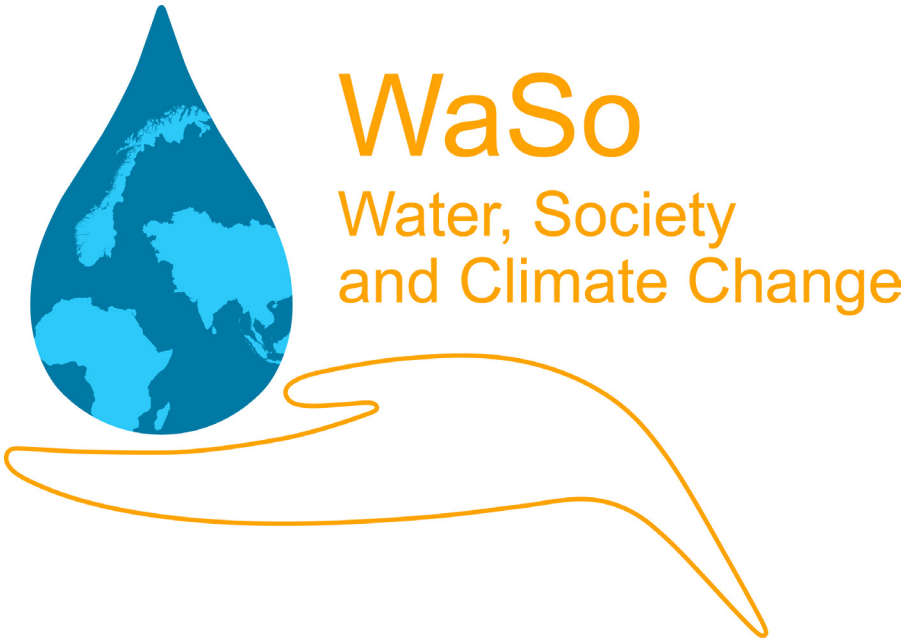

User Allocation and Implication on Water Quality and Farm Income: The Lower Chenab Canal Irrigation System in Pakistan

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The irrigated agricultural sectors in many countries are challenged by the low crop yields and declining agricultural production, which questions the food security. This is exacerbated by unequal distribution of the canal (surface) and ground water along the irrigation systems and the water quality (salinity) but inadequately addressed in scholarly work. An economic modelling for various water use scenarios have been developed to address the problem of inequality in water use and impact of salinity on crop yield (such as wheat). These models were estimated through a socio-economic farm household survey conducted in three locations: head, middle and tail reaches of the Lower Chenab Canal (LCC) irrigation system in Pakistan. A multistage stratified random sampling method was conducted to collect data from 256 farm households during 2010-2011 and 2012-2013 cropping sessions, respectively. The models were estimated by regression analyses for the effect of water quality on the crop yield under different water use scenarios. For each scenario, the canal and ground water use were defined as the percentages of total water use. The base scenario for instance included 60:40, 50:50, and 30:70 percentages of the canal and ground water use at the head, middle and tail locations, respectively. The optimal water use model implies that the use of more ground water for the head distributary is advisable (30:70) whereas the tail distributary can utilize more canal water (70:30). Further the gross margins (farm incomes) estimated for the distributaries suggest that farmers could be better off under the optimal water use scenario among all the other scenarios tested. The optimal water use scenario can significantly reduce the negative effect of salinity on crop yield and improve farm income. The modelling approach developed in this study can be useful to design better water use scenarios for other crops and areas facing similar issues.

Keywords: Crop yield, Groundwater, Irrigation, Socio-economic impacts, Water quality

Impacts on Irrigation Infrastructure Development Projects on Agriculture sector: A Case study in Iranamadu Irrigation Scheme of Sri Lanka

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Agriculture sector development to ensure food security for escalating population inevitably requires Irrigation infrastructure development. Recognizing this fact, both Government and Donors make significant investments in irrigation development in developing counties.In the recent times, the funding agencies show lack of motivation in investing on irrigation development projects due to high likelihoods of uncertainty on the return of investments. To convince them about the positive impacts and to attract them, an impacts needs to be assessed on irrigation development and management. As such, this case study was undertaken in recently developed Iranamadu Irrigation Scheme, which is the largest reservoir in the Northern Province, to irrigate 8698 ha of paddy and other field crops by both gravity and lift irrigation facilities benefitting 7000 farmers. With the intervention of Asian Development Bank (ADB) and the International Fund for Agriculture Development (IFAD), investing 42 Mn USD, scheme has been rehabilitated and augmented recently. After the project completion in year 2018, significant improvement has been observed in agricultural development. This study is based on scientific parameter; cropping intensity, water duty and productivity which are the main indicators for the Irrigation investment. A scientific methodology is developed to compare parameters before and after project implementation in both *Maha* and *Yala* seasons, in order to examine the impact on the irrigation development programme. The results of the analysis revealed that positive impact is there immediately after project completion; especially cropping intensity has increased drastically by 0.40 (from 1.30 to 1.70), reaching 1.7 which is more than the national average for the major irrigation schemes, though irrigation impact is long term. The significant incremental benefit agriculture investment has a positive economical impact thus encourage agencies to invest more on irrigation development projects.

Keywords: Augment, Development, Intervention, Downstream, Irrigation, Productivity

Analysis of Drought Condition in Kilinochchi Districts by Standard Precipitation Index

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Drought is a major environmental hazard related with water scarcity and it is a complex phenomenon due to its severity, duration and aerial extent. Agriculture sector is most affected by the onset of drought as it is a highly reliable on the weather, climate and soil moisture. Kilinochchi is one of the most agricultural area in Northern and its rainfall characteristics are different from other regions of Sri Lanka. Therefore, the study aims to evaluate the drought in this area in different time scales; which represent the impact of drought in different sectors and water resources. To achieve this objectives the rainfall data for the period of 1988 to 2018 (30 years) was collected and analyzed using standard precipitation index with different time scales; 1, 3, 6, 9 and 12. The results shows that the monthly average rainfall for the 30 years ranged between 9.409 to 304.177 mm. Most of the data falls under extremely drought condition this is followed by near to normal condition. In the extremely drought condition the occurrence of SPI values recorded as SPI 6 > SPI 9 > SPI 12 > SPI 3 > SPI 1. The distinct heavy changes in the precipitation over the study area with the percentage of 50.1 % (SPI 6) and it has impact on agricultural activity and the area also has high impact on stream flows, reservoir levels and ground water level (SPI 12, 50 %), these events followed by SPI 3 that indicates the impact of drought on seasonal estimation of precipitation and impact on short term soil moisture and crop stress (SPI 1, 43.5 %). From this study it can be concluded that the area has high impact due to extremely drought and high risk in short term soil moisture deficit, which may adversely affect the agricultural activity.

Keywords: Drought, Kilinochchi, SPI

Up-scaling Water Saving Technologies in Rice Cultivation Under CSR (Corporate Social Responsibility)

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Rice is the principal food crop grown all over 29 districts of Tamil Nadu state in India. Rice crop being the major consumer of water, the water use efficiency of growing rice crop is low compared to other field crops. The promising technologies on water saving in rice were advocated to the farmers on corporate social responsibility basis by upscale and popularisation of these techniques among poor land holding farmers in rice growing locations of Villupuram district of Tamil Nadu State in India. The main objective of the study was to bring awareness among rural farmers on water saving technologies in Rice production, thereby increasing water usage efficiency and enhanced grain yield. Field demonstrations were carried out in 25 locations each separately in Villupuram district for up scaling water saving technology in rice cultivation like System of Rice Intensification (SRI) and Alternate Wetting and Drying Irrigation (AWDI). The bio-metric observation data was recorded in the embarked area in the demonstration field plots conducted in 25 locations. The average mean data was computed and used for analysis. In SRI demonstrations, the conventional planting system recorded water requirement from 1200-1390 mm compared to 850-1050 mm of water requirement in SRI. Quantity of water required to produce one kilogram of rice was 2200-2950 L in conventional planting compared to 1440-1880 L in SRI system. The number of irrigations recorded were 24-30 in conventional planting and 15-24 irrigations in SRI. There was water saving of 350 mm recording 29.16 percentage. In AWDI demonstrations, the normal irrigation system recorded water requirement from 1200-1350 mm compared to 750-1050 mm of water requirement in AWDI. Quantity of water required to produce one kilogram of rice was 2300-2900 L in normal irrigation system compared to 1300-1900 L in AWDI. The number of irrigations recorded were 24-30 in normal irrigation system and 15-24 irrigations in AWDI. There was saving of 270 mm to 350 mm water per hectare area. Increase in the grain yields obtained with water saving made the farmers confident on the water saving technologies.

Keywords: Rice crop, Up-scaling, Water saving technology

Phytoremediation of Farm Wastewater by Selected Aquatic Plants

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Wastewater is the main source for the pollution of surface waters and treating wastewater is an essential process to reduce the environmental hazards. Wastewater management has a direct impact on the biological diversity of aquatic ecosystems, disrupting the fundamental integrity of our life support systems on. When water bodies receive excess nutrients through wastewater, especially nitrates and phosphates, can stimulate eutrophication. Eutrophication leads to excessive plant growth, especially algal blooms, oxygen depletion, decreased biodiversity, changes in species composition and dominance, and a severe reduction in water quality. Although there are natural causes, much of the eutrophication seen today is a result of inadequately treated wastewater and agricultural runoff. Moreover, aquatic plants, mostly weeds grow profusely in lakes and waterways all over the world and in recent decades their negative effects have been magnified by man's intensive use of water bodies. Eradication of such aquatic weeds has proved almost impossible and even reasonable control is difficult. Turning these weeds in to productive use would be desirable, if it would partly offset the costs involved in mechanical removal of those from water bodies. Therefore this study was conducted to assess the water purification ability of five selected aquatic plants; *Duckweed, Waterhyacinth, Azola, Salvinia* and *hydrilla.* Reduction of nitrate, phosphate, EC, TDS, pH in wastewater collected from an animal farm by these weeds separately were tested. Most of the aquatic plants show better performance in water purification process. During the experiment period 87.5 % of nitrate and 67 % of phosphate have been absorbed by the aquatic plants and 25 % reduction of EC and TDS was also observed. Alkaline pH has changed to neutral. Duckweed and Water hyacinth show higher pollutant removal efficiency and highest performance in survival among these aquatic plants. *Azola* performs a considerable pollutant reduction than others plants. Whereas *Salvinia* performs the lowest reduction rate compared to other aquatic plants. In addition to that, *Hydrilla* performs the highest reduction of water pH. In this study phytoremediated wastewater, which consists permissible levels of pollutants can be used for the irrigation of farm plants without any physiological stress.

Keywords: Aquatic plants, Phytoremediation, Pollutant removal, Water quality parameters

Low Cost Algal Removal Method for *Dri Aru* Water Treatment Plant

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Removal of algae plays an important role in the water treatment industry to maintain a system with higher efficiency and to prevent the release of algal toxins. A water treatment plant in Kilinochchi was taken as case study as the plant had serious algal overgrowth issues within the system as well as in the intake (*Dri Aru* tank). The aim of the research is to find the root causes for excessive algal growth in the *Dri Aru* tank and to propose a cost effective treatment method for algal removal in the plant. Water samples were collected from 10 locations at tributaries of *Dri Aru* tank and the concentration of Nitrate and Phosphate was measured using colorimeter to compare the locations of higher nutrient supply. For the treatment method, adsorption of coconut shell based Granular Activated Carbon (GAC) was selected (size range: 0.6 mm - 2.3 mm) to perform Batch scale and Column scale experiments. The results showed, the *Dri Aru* tank has a source of Phosphate supplement with concentrations above 0.5 ppm (Standard limit: 0.05 ppm) at Kilinochchi town rear side and supply channel from Iranamadu to *Dri Aru* tank. Based on adsorption batch studies the optimum dose and contact time were 20 g/L and one minute respectively. Based on the R^2 values of Langimuir, Freudlich, Temkin and Dubinin – Radushkevich isotherms, Temkin isotherm was selected as the best fitting model. The adsorption capacity of selected GAC was 0.17 g/L and 0.16 g/L for chlorophyll and cells respectively. The GAC fixed bed column (15 cm diameter and 70 cm height) running at the flow rate of 17 mL/min for 120 hours, resulted to the maximum removal efficiency of 92 % and 95 % for chlorophyll and cells respectively at 52 hours and the minimum removal efficiency was 58 % at 120 hours. Thus, the coconut shell based GAC can be used as an adsorbent to remove algae in water treatment plants to improve the efficiency of the system. However, the GAC fixed bed column was inefficient in removing the algae types such as *Gomphoshaeria, Osilatoria* and *Microcystis* after 120 hours of operation.

Keywords: Adsorption, Algae, Granular activated carbon, Isotherm, Water treatment

Operational Performance of Up-Flow Filters for the Treatment of Iron from Synthetic Groundwater

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The most commonly used iron (Fe) removal mechanisms of groundwater involve oxidation-precipitation, electro-coagulation and floc-filtration worldwide. In this study the performance of two different filter media were examined by investigating the removal of Iron (Fe) from synthetic groundwater (SGW) using vertical up-flow filtration technique. Granular Activated Carbon (GAC) particles with the sieve range of 0.8 mm to 2.36 mm, and bio-pac media (BPM) made of Poly-propylene, of size 14 mm x 10 mm (diameter x height) were separately used in column experiment with 80 cm media height for the comparison. Trials were done in 3 different phases for 48 hours duration. In Phase 1 initial Fe concentration had been increased from 1 to 3 mg/L at 7 hours HRT (hydraulic retention time) and in Phase 2 the HRT was reduced from 7 to 3.5 hours with influent having Fe equal to 3 mg/L. Finally, in Phase 3, columns were operated with an air supply from an aquarium air pump with 2.5 L/min along with 3 mg/L influent Fe at 7 hours HRT. The results showed that at the Phase 1 increase of the initial Fe concentration from 1 to 3 mg/L had increased the Fe removal efficiency from 95 % to 98.9 % for GAC filter media while BPM showed a little increment from 69 % to 71 %. Also it was noted that, at the Phase 1, though effluent of GAC filter had met the WHO drinking water standard of 0.3 mg/L for Fe removal, BPM had not met the standard. At Phase 2, it was observed that Fe concentration at the effluent had increased in both filters, with HRT reduction from 7 to 3.5 hours. Finally, at phase 3, it was noted that there was no positive effect of aeration on Fe removal in both filters. Instead, an increment of effluent Fe concentration had observed for both filters and oxygen transfer efficiency is the main factor determining the effective performance of the filter which depends on air/water ratio. The increased air/water ratio of 100:1 was found to be improper in this study and reduced the filter performance. Overall, up-flow filters showed better performance for GAC compared to BPM on Fe removal.

Keywords: Bio pac media, Fe removal, Granular activated carbon, Synthetic groundwater

A Comprehensive Water Safety Plan for Kilinochchi *Dri Aaru* Water Supply Scheme

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The safe drinking water is essential to human health but water borne disease is one of the major health problems worldwide. In Asian countries, safe drinking water supply at household level is limited and the rural area people use drinking water from unprotected wells, springs and surface water without any treatment. Due to this reason, World Health Organization (WHO) proposed the water safety plan to assure the safe drinking water to all. Specially, in the Northern Province of Sri Lanka, a comprehensive water safety plan has never been practised. However, there is an essential for a water safety plan to ensure the safety of drinking water through the use of a comprehensive risk assessment and risk management approach that encompasses all steps in water supply from catchment to consumer. This research study focused on preparing a comprehensive water safety plan in wet season for Kilinochchi *Dri aaru* water supply scheme with the risk analysis of potential contaminants, physical hazards and chemical hazards at catchment level, treatment level and distribution level. A number of water quality parameters including pH, electrical conductivity, salinity, total dissolved solids, temperature, total iron, total phosphate, total nitrate, total nitrite, total sulphate, total fluoride, free chlorine and turbidity were measured. The results showed that deviation of total iron and total phosphate are slightly above the standard level as prescribed by WHO but the level of salinity is identified as 150 ppm whereas it should have been 40 ppm. So, it was concluded salinity is the main factor that affects drinking water quality. The sources of potential contaminant were also identified with the point of contamination.

Keywords: Catchment, Hazard risk assessment, Treatment

Impact of Sprinkler Irrigation on the Productivity of Red Onion in Jaffna District

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Onion (*Allium cepa* L.) is one of the most important cash crops in Jaffna district, and Jaffna red onion is a well-known commodity throughout the island. Ground water is the major source of water for all activities, including agriculture in Jaffna district. Irrigation cost of onion production is one of the major components of cost of production. Due to inefficient irrigation methods, many places of Jaffna district face a shortage of groundwater for irrigation in dry season. The major objective of this study is to determine the impact of sprinkler irrigation on onion production. Two hundred farmers who cultivate red onion in Valikamam, Thenmaradchi and Vadamaradchi areas of Jaffna district were randomly selected for this study. A structured questionnaire was used to collect the data from the sample. An explicit Cobb-Douglas stochastic frontier production function was estimated to analyse the impact of sprinkler irrigation method on onion production. The results show that the coefficients of extent of cultivation, organic fertilizer, sprinkler irrigation method, and soil type were significant at 5 % level. One percent increase in extent of cultivation and the amount of organic fertilizer increase the onion production by 0.7 % and 0.13 % respectively while other things are equal. The coefficient of inorganic fertilizer is insignificant in this model. All the farmers in the sample apply inorganic fertilizer more than the required level. This may be the reason inorganic fertilizer to be significant in this model. The coefficient of sprinkler irrigation method indicates that onion cultivation with sprinkler irrigation method averagely produce 23 % higher yield compared to onion cultivation with basin irrigation method. The average onion production efficiency in the sample is around 78 % with minimum efficiency of 30 % and a maximum of 92 %. Therefore, there is a high potential to increase the efficiency of onion production through the sprinkler irrigation method as well as save the water.

Keywords: Red onion, Productivity, Groundwater, Sprinkler irrigation

Agribusiness Management, Agricultural Economics and Extension

Mapping High-Potential Areas of Pineapple Cultivation in Sri Lanka by using MaxEnt Model and Constraints Analysis

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Although pineapple is a major commercial fruit in Sri Lanka, it is widely growing only in Gampaha and Kurunegala districts. But it can be expanded to other districts as well. This study was aimed to model the high-potential areas of pineapple cultivation in Sri Lanka using MaxEnt model which has great potential for identifying best ecological requirement of species based on "presence only data" together with environmental variables. Data on 215 GPS pineapple cultivation locations covering whole Sri Lanka and raster environmental layers for monthly rainfall, monthly mean temperature, Digital Elevation Model (DEM), slope, slope facing direction and Normalized Difference Vegetation Index (NDVI) were used for this study. The resulting model was validated by using area under the receiver operator characteristic curve analysis and jack-knife test. In addition to mapping, a questionnaire survey was conducted with a sample of 60 farmers in four divisional secretariat divisions of Gampaha and Kurunegala districts to explore prevailing conditions and constraints of pineapple cultivation. Highly significant constraints were identified using Wilcoxon signed rank test. Probability prediction map developed by MaxEnt with high predictive power (AUC = 0.913) indicated that some parts of Ampara, Monaragala, Puttalam Colombo and Kaluthara districts as high potential areas in addition to Gampaha and Kurunegala districts. According to jackknife test, mean temperature in drier months and total rainfall during wet months showed relatively high correlation for the pineapple growth. Wilcoxon signed rank test proved that high cost of inputs, high price of mulching materials, shortage of labours, high investment, lack of government subsidy facilities, weed problems and threat of mealy bug attack as highly significant production constraints while lack of guaranteed price as the major marketing constraint for pineapple cultivation ($P < 0.05$). These predicted high-potential areas of pineapple are useful for farmers, investors and entrepreneurs to take information-based cultivation decisions.

Keywords: Global positioning system, MaxEnt model, Pineapple cultivation, Probability mapping

Pricing to Market and Exchange Rate Pass through in Sri Lankan Crepe Rubber Export Markets

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This article analyses the Pricing to Market (PTM) strategy for Sri Lankan crepe rubber. The fluctuation in the value of the Sri Lankan rupees can alter the prices of exported goods in terms of foreign currencies and in turn could lead Sri Lankan products either more or less expensive to foreign buyers and consequently affecting export demand. The analysis of PTM effects is therefore an important element in assessing the relationship of exchange rate and export prices of tradable goods. A within and between model of panel regression is used to analyse the exchange rate pass through of Sri Lankan crepe rubber in the world market. A within model is used to analyse the short-run pricing-to-market and between model is used to analyse the long-run pricing-to market. Eight export market destinations data form 2003 to 2014 were selected for analysis. These results clearly imply that the pricing-to market is strategically viable plan to expand the Sri Lankan crepe rubber market in short run.

Keywords: Crepe rubber, Panel data, Pricing

Assessing the Factors Affecting Labour Productivity of Tea Harvesters in Up Country Tea Plantations in Sri Lanka

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Recently tea sector in Sri Lanka has experienced diminishing labour productivity and profit. Improving profitability by increasing the labourers' efficiency is a way to maintain tea productions for long term sustainability. The objective of the study was to estimate the current level of labour-productivity and to identify the factors affecting labour-productivity of tea harvesters as it brings a paramount importance to the tea sector. The primary data were collected by means of a structured questionnaire based personal interviews carried out with 350 individual tea pluckers. Secondary data were collected from administrative units from the tea estate located in Nuwara Eliya district in August 2018. As a core part of the study, five different indices were developed namely Household and Housing (HH), Worker Skills Development (WSD), Individuals' Health Level (IHL), Availability of Finance (AF), Working Environment and Conditions (WEC) by considering major areas affect on productivity which are bound with their livelihood. Quantile Regression was used to assess the differing impacts of these five indices on labour productivity with respect to three different quantiles (*i.e.* 25^{th}, 50^{th} and 75^{th}). The outcome of the analysis suggested that HH and WSD were able to make a significant effect on all three different productivity levels. The contribution of the HH and WSD were higher with the percentage of labour-productivity. IHL and AF indices were significant only in 25 % productive category and WEC index was significant in 75 % productivity group. Results claimed that, different productivity levels should be addressed to uplift the labour-productivity since their desires are quite different. Administrative unit of the estate should focus on encouraging labourers' performance by addressing productivity intervention areas as offering incentives for the highly productive pluckers, providing training opportunities and encouraging to participate in training programmes, influencing them to obtain medical aids from the estate and to maintain a good health condition.

Keywords: Labour productivity, Principal component analysis, Quantile regression, Tea industry

Assessing the Effect of Land Tenure System on Climate Change Adaptation Practices Among Rice Farmers in North-West Nigeria

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This study was conducted to assess the effect of land tenure system on climate change adaptation practices among rice farmers in North-West Nigeria. It specifically described the land tenure system of the farmers, their use of climate change adaptation practices and the relationship between land tenure system and use of climate change adaptation practices by the farmers. The study covered Sokoto, Kebbi and Zamfara States in North-West, Nigeria. A multistage sampling procedure involving a purposive selection of 9 Local Government areas, 16 villages and finally a random selection of 522 farmers was used for the study. Data were obtained with the aid of structured questionnaire from August, 2016 to January, 2017. The data were analyzed using both descriptive (frequency counts, percentages, ranges and means) and inferential (Tobit regression analysis) statistics. Results of the study revealed that majority (93 %) of the farmers acquired land through inheritance, owned 1-4 ha (86 %) of which less than 01 ha was cultivated for rice production (62 %). Result of the Tobit regression analysis showed that both purchased and rented land had positive and significant ($P < 0.01$) influence on the farmers' use of climate change adaptation practices which was measured by development of a Composite Index (CI). It was concluded that use of climate change adaptation practices by rice farmers in North-West Nigeria is largely influenced by land tenure systems in the region. Land tenure by inheritance particularly, has a negative influence on use of climate change adaptation practices in the area. The implication is that unless the current land tenure system (inherence) for rice production is reformed, land might not be readily available for rent or purchase especially to non members of community who are more willing to use the climate change adaptation practices for increased productivity.

Keywords: Adaptation, Climate change, Land tenure system, North-West Nigeria, Rice farmers

Impact of Individual Characteristics of AIs on Knowledge Transfer Process

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Agriculture extension services are designed to enable the diffusion of knowledge about farm technology. Agriculture Instructors (AIs) act as bridges between researchers and farmers implying that their capacity to absorb and diffuse knowledge is crucial for the effectiveness of the entire knowledge dissemination process. Despite the vast amount of research done on organizational dimensions on knowledge transfer, few studies address individual dimension in general and the role of knowledge transfer in particular. In this study, we examine the extent to which individuals' capability to identify, assimilate, utilize and transfer new knowledge from external environment is shaped by their motivation, ability and opportunities drawing on MAO (Motivation, Ability and Opportunity) framework. To explore this, 72 AIs in the Southern province of Sri Lanka were surveyed using a semi-structured questionnaire. Multiple regression model was used for our analysis and first we tested basic four assumptions of regression analysis. This study found a positive and statistical insignificant effect of individual Ability on knowledge transfer process (β=0.183, $P > 0.05$). Further, we found that individual motivation has a negative, statistically insignificant impact on knowledge transfer (β=-0.008, $P > 0.05$). Moreover, Opportunities show positive and significant impact on transfer process (β=0.039, $P < 0.05$). Therefore, study has concluded that individual ability and opportunities positively impacted on knowledge transfer process of AIs in Sri Lanka. Based on these research findings, the Government in Sri Lanka should not emphasize motivation to the AIs as the primary mechanism for improving their performances and Instead, the government should stimulate their interest by developing and sustaining opportunities through social interaction.

Keywords: Ability, AI officers, Knowledge transfer, Motivation, Opportunity

Socio-economic Characteristics and Status of Food Insecurity: Evidence from Rural Households in Sri Lanka

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Recent attention has been focused on means of eliminating food insecurity and hunger worldwide. Food security can be explained as food that is available to everyone at all times, that they have means of access to it, that it is nutritionally adequate in terms of quantity, quality and variety, and is acceptable within the given culture. Absence of these conditions is considered as food insecurity. Aim of this study was to identify determinants of food insecurity status of rural households in Sri Lanka by using household income and expenditure survey data, a nationally representative data. The analysis was carried out in two stages. In the first stage, food insecurity index was determined and in the second stage binary logistic regression model was executed to estimate the food insecurity status of the households as a function of a set of independent variables. Food insecurity index was determined by using a proxy variable based on the percentage of each household's total expenditures devoted to food. Descriptive statistic results indicate that the percentages of food insecure and secure households were 54 % and 46 % respectively. The two sample t test results suggested that there is a significant mean difference in human capital variables between food secure and food insecure households. The results of the binary logistic regression model revealed that household head being female, younger and educated will decrease the vulnerability of household to become food insecure and if a household have higher number of members who complete the secondary education, higher number of workers, lower young dependents and higher old dependents will reduce the food insecurity status of rural households in Sri Lanka. In conclusion, the findings of this study support the empirical literature on the importance of human capital development in food insecurity status.

Keywords: Food insecurity index, Household income, Expenditure survey, Logit regression, Rural households

Role of Under-Utilized Crops in Food Security, Nutrition and Resilience in Dry Corridor of Sri Lanka

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The world depends for its basic diet of carbohydrates, fats, and proteins on a very limited number of crop species. Underutilized crops species are often indigenous wild crop relatives which are still used at some level within the local, national or even international communities, but have higher potential to contribute to the food nutrition and security. Present approach is to identify the role of underutilized crops in food security, nutrition and resilience while developing food availability and food deserts maps to Uva and Eastern provinces. Mixed methods approach was employed and sample size was 450. Farm households were selected form each province. Key informant interviews, focus group discussions, interviewer administered questionnaires were main data collection tools. Maps of food deserts and food availability were developed through Arc GIS 10.4. Food availability map graphically illustrates the commercial crop growing areas and locations of food sources in each province. Food desert map highlighted the areas where consumers who did not have access, affordability and availability for food. Backyards and its underutilized crops bridge or reduce the food availability gap. Underutilized crops were playing a major role by providing diversified meal, while generating extra income (10,000-25,000 LKR/season). Multi-purpose backyard underutilized crops bring various benefits; diversified nutrients and meals, economical, eco-stability, contributed to gene pool. Sustainability index selected best crops for each district. Scoring technique was adopted to weigh each variable and total score were derived for each crop. There were 30 %-27 % of food deserts located in each province due to long distance to food sources, low household income levels, poor road access and not having own vehicles for transportation. Even though they did not have access for proper nutritious food consumption their backyard, endemic and natural underutilized crops provide considerable contribution to fulfill their nutrition needs and secure them with diversified daily food consumption.

Keywords: Food desserts, Food security, Sri Lanka, Underutilized crops

Battle between Gem Mining and Small Holder Agriculture Systems: A Case Study of Selected GN Division on Rathnapura District in Sri Lanka

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Gem mining is a sector that is inherently dependent on the natural environment and requires a natural conditions including habitable climate, access to water resources and supporting infrastructure to extract the resources. Over exploitation of these natural resources had led to disastrous consequences including climatic change and low agricultural productivity. It was deeming appropriate to study on the impact of gem mining on the agricultural sector and the small holders who are the immediate beneficiaries of the sector. The study attempted to find out the agricultural land availability, quality of lands, soil erosion, water quality and labour migration from agriculture to mining. The study was conducted in three GN Divisions of Rathnapura district including *Elapatha*, *Pallegedara* and *Dellaboda*. Sample consisted of 100 farmers collected through the convenience sampling. Focus group discussions and key informant interviews with farmers, field level instructors and gem miners were conducted to collect data. The data was analyzed using descriptive statistics and spearman correlation. Study revealed that all farmers believed that mining operations were one of the major reasons for the occurrence of frequent floods and landslides in the study area. Poor mining operations had led to soil erosion, sedimentation, removal of vegetation that resulting the reduction of availability of lands for agricultural, quality of land and water. The percentage of the barren paddy lands of *Pallegedara, Dellabada, Elapatha* are 7, 20 and 26 % out of the total paddy lands respectively. The average paddy yield of the study area for the year was around 50 bushels/acre in the *yala* season and 60 bushels/acre in the *Maha* season. The frequent floods had destroyed critical agricultural assets and infrastructure, disrupting production cycles, trade flows and livelihoods means of the study area. Further, small- and large-scale illegal mining is widespread despite of regulatory measures. The respondents believed that the license holders also neglect the license rules in the greed of earning high profit. This had affected the farming systems and causes additional disruptions throughout the value chains while shifting the labor away from the agriculture sector. However, the registered farmers out of the total population of the *Pallegedara, Dellabada and Elapatha* GN divisions counts as 4, 15 and 15 % respectively, emphasizing that the likelihood of people for farming is limited to a small percentage. Therefore, proper management and monitoring must be maintained by the relevant authorities to mitigate the aftermath impact of mining. Further, the local community should be empowered to raise their voice against gem miners who do not abide by the required regulations during the process of mining.

Keywords: Agriculture systems, Gem-mining, Small holder

Impact Assessment Oil Mill Layout on Production Cycle Time and Output Quality

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Cinnamon leaf oil is produced by steam distillation of dried leaves on rather simple, but nevertheless effective, equipment. Eugenol content (60-65 %), while the oil produced in the Ambalangoda and Matara of the extreme south was darker and contained 75 – 80 % of eugenol. Study aimed to conduct impact assessment of oil distillation unit layout on production cycle time, efficiency and output quality of cinnamon oil. Study sample composed of 45 cinnamon oil distillation units located in Galle and Matara districts and focus group discussion, in depth interviews, pre tested interviewer administrated questionnaires were main data collecting tools. Leaf oil is a product of the leaves and twigs, by product of cinnamon processing industry. Cost of raw material is negligible and the only costs encountered were the cost of labour for collecting leaves, bundling and the distillation. Poor efficiency, low productivity, poor quality and high cost of production were common issues of cinnamon oil distillation. Average production cycle time was 4-7 days including the collection and weathering time of leaves. The traditional stills used by many distillers were large wooden vessels capable of holding a charge of about 200 kg of leaves. Steam is generated in a separate wood-fired boiler and the leaves are distilled usually for 8 to 9 hours. Average oil yield was 4-6 bottles and oil yield and quality varied with geographical location, cultivar and method of distillation. Efficiency, cost of production, oil quality varied in traditional oil distillers with improper distillery layout and modernized distillery layouts.

Keywords: Cinnamon leaf oil, Cycle time, Factory layout, Oil distillation

Cinnamon Oil Value Chain: An Investigation of Key Success Factors, Strategic Intervention for Value Chain Upgrading

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Cinnamon oil and oleoresin cover a broad range of products, used primarily as flavors and fragrances, but cinnamon oil has a long history of traditional usage as medicines and food supplements to support good health. Study focused to investigate the cinnamon oil value chain; map the value chain, find out the functions, actors and products, value and volume flow, and income distribution along the value chain. Study heavily based on primary data collected from cinnamon oil value chain actors of Galle and Matara districts of Sri Lanka. Purposively selected 45 cinnamon leaf and bark oil distillers, local collectors and exporters were the respondents. The main data collecting tools were interviewer-administrated questionnaires, in depth interviews and focus group discussion. Cinnamon oil value chains were lengthier, fragmented, leading to low levels of traceability in terms of quality and quantity. Trust, information and knowledge sharing, quality compliance was poor among value chain actors. The chain generally involves cinnamon farmers, distillers, collectors, processors and exporters. Value chain supporters and influencers were mainly government institutions with over lapping mandates but fragmented service providers. Cinnamon oil and oleoresins were highest gainers of cinnamon industry catering to the USA and EU markets mainly. The cinnamon oil consumption in many developed as well as developing nations has increased in past few decades due to rising healthcare awareness and its other beneficiary effects on mind and body and its extensive use in aromatherapy.

Keywords: Cinnamon oil, Sri Lanka, Value chain

An Assessment on Non-Adoption of Compost Making in Kilinochchi District, Sri Lanka

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Waste Management Authority and the Central Environmental Authority recorded in 2018 that, 7500 MT solid waste generation per day in Sri Lanka. However, only 3500 MT is collected by local authorities and remain accumulates in the households. This proves for the requirement of a proper waste management mechanism to be established at the household levels. This study aims to evaluate the present knowledge on home waste management and divergent contentions for non-adoption of compost making and suggestions for altercations of future adoption in households. Qualitative data collection techniques including Focus Group Discussion (FGDs), Participatory Rural Appraisal techniques (Transect walks, pair wise ranking and resource map) and written test were employed. Equal representation of men and women in FGDs were confirmed from Piramanthanaru farming village (15 men and 15 women). Decomposition rate of home wastage, methods of compost making, application of compost and it's importance were questioned specifically from each respondent. The results revealed that minority (30 %) obtained approximately 50 % from the total marks yet others scored less than 10 %. Majority of households use polybags as the fuel in cooking depicting lack of knowledge on hazardous impact of this activity. Decomposable home wastages like crop residues, paddy husks, papers and weeds used to burn. e-waste accumulate at a considerable level at the household level mainly due to the absence of a collecting practice adopted by any local authority or the village itself. Lack of awareness on compost application and its importance, lack of awareness on compost making methods, and requirement of bulk quantities of compost for commercial agriculture were ranked as first, second and third reasons for the non-adoption respectively. Improved agricultural extension services, regular training and development, and inclusion of solid waste management into the formal education system were suggested to overcome these constraints. To sum up, by reducing uncertainty on soild waste management at household level, the level of adoption on compost making can be improved. In recommendation, integrated waste management should be all rural part of the country as well.

Keywords: Compost, Kilinochchi, Participatory Rural Appraisal, Waste Management

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