ICDA 2020

6TH INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE

CONFERENCE PROCEEDINGS

3rd & 4th December 2020

Volume - 06

Faculty of Agriculture, University of Jaffna, Sri Lanka.

6th INTERNATIONAL CONFERENCE ON DRY ZONE AGRICULTURE

(ICDA 2020)

"Resilient Agriculture to Cope with Unforeseen Crisis'"

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Sri Lanka

ISSN: 2465-6143

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Organizing Committee
ICDA Secretariat,
Faculty of Agriculture,
University of Jaffna,
Sri Lanka

Published by
Faculty of Agriculture, University of Jaffna, Sri Lanka

URL: http://www.conf.jfn.ac.lk/icda2020/

Printed by
Mathi Colours, No. 10, Murugesar Lane, Nallur

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MESSAGES

Message from the Chief Guest

Prof.S.Srisatkunarajah
Vice Chancellor
University of Jaffna
Sri Lanka

It is with immense pleasure that I write this message for the 6th International Conference on Dry Zone Agriculture (ICDA 2020) hosted by the Faculty of Agriculture, University of Jaffna. In the past years, this annual conference provided a venue for local and international researchers who study the agrarian practices and agrarian economy of the dry zone of Sri Lanka to disseminate their scholarship and exchange their ideas. I am hopeful this year's conference too will lead to productive conversations and future collaborations. Agriculture is a key instrument in ensuring food security in the dry zone of Sri Lanka. It remains the livelihood of majority of the people in this region. In addition to the climate changes, the ongoing COVID 19 pandemic has impacted the agriculture sector of Sri Lanka's Dry Zone adversely. In this context, the theme of the conference, "Resilient Agriculture to Cope with Unforeseen Crisis" is of timely significance. Located in Kilinochchi, which is considered the rice bowl or the granary of the Northern Province, the Faculty of Agriculture of the University of Jaffna plays an important role in re-fashioning and strengthening the agricultural activities of the North. Rebuilding an agrarian economy in the post-war contest is not an easy task. It involves not just the invention and implementation of sound, eco-friendly agricultural practices but also addressing inequalities related to landownership and building self-sufficient agrarian communities. In Kilinochchi, for instance, the landlessness among a significant amount of population that inhabits the district at present is a major hindrance to the development of agriculture. The Malaiyaha Tamil communities who moved to the district in the aftermath of the anti-Tamil violence of 1983 continue to face the problem of landlessness. Addressing these issues are important to develop an agrarian economy that ensures both food security and livelihood security. Such a context calls for radically new scholarly and policy approaches. I am optimistic that this conference will be a step towards exploring solutions to the challenges faced by dry zone agriculture and the communities that are at the heart of this sector.

I congratulate the Dean of the Faculty of Agriculture and the organizing committee of the ICDA 2020 for organizing this landmark conference and wish the conference and its participants all success.

Message from the Conference Chair

Dr.K.Sooriyakumar
Dean
Faculty of Agriculture
University of Jaffna
Sri Lanka

On behalf of the Faculty of Agriculture I warmly welcome you to the 6th International Conference on Dry zone Agriculture (ICDA 2020). It is indeed a privilege and pleasure to deliver this message as a Dean of the Faculty of Agriculture on the occasion of the 6th International Conference on Dry zone Agriculture 2020 scheduled to be held on 3rd and 4th December 2020. I consider this as one of the most important events in the faculty calendar. As in previous years ICDA 2020 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 "Resilient Agriculture to Cope with Unforeseen Crisis". Agricultural production will be affected by many changes in its climatic, agronomic, economic, and societal contexts. Therefore, there are opportunities for breeders to play an active role in the development of an ecological and societal resilient sustainable agriculture. Plant breeders need to produce cultivars that strengthen both ecological and societal resilience by endeavoring for food security, safety and quality, food and seed sovereignty, social justice, agro-biodiversity, ecosystem services and climate robustness. The development of an ecological and societal resilient sustainable agriculture is only possible with substantial and long-term efforts from all the players in the food system: agronomist, plant breeders, scientists, processors, retailers, and consumers. All players in the food system must find ways to mitigate the negative effects of climate change. Objective of increasing yields should not go to the detriment of nutritional quality, taste and other food qualities.

The ICDA 2020 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 Vice Chancellor, Professor Sivakolundu Srisatkunarajah for his enormous support. Let me also take this opportunity to thank our Guest of Honour, Keynote Speakers, Chair of the sessions, Sponsors and Members of organizing committee as well as everyone who helped in numerous ways to make ICDA 2020 a success. While warmly welcoming all delegates to ICDA 2020, I hope that participation at ICDA 2020 will be a rewarding experience to you.

Message from the Convener

Ms.S.Sivakanthan
Department of Agricultural Chemistry
Faculty of Agriculture
University of Jaffna
Sri Lanka

I am delighted to welcome you all to the 6th International Conference on Dry Zone Agriculture (ICDA 2020) hosted by Faculty of Agriculture, University of Jaffna. As part of its commitment to respond to issues related to dry zone agriculture, the Faculty of Agriculture organizes the International Conference on Dry Zone Agriculture as an annual event. This conference aims to provide an open forum for eminent scholars from different disciplines to disseminate their research findings, share ideas and experiences and use the novel knowledge stemming from their work for practical outcomes.

During this year's conference, five distinguished guests and sixty six researchers will share their knowledge and research findings under the theme of "Resilient Agriculture to Cope with Unforeseen Crisis". Despite the prevailing Covid 19 pandemic, the committee managed to organize this event successfully with a significant number of research papers. Beyond a shadow of doubt, I believe that this annual conference will continue to be alive in the years to come.

I am deeply grateful to the guests for gracing this event. We are especially honoured and delighted to have the privilege of the presence of our Guest of Honour, Dr.W.L.G.Samarasinghe, Additional Secretary (Agriculture Development), Ministry of Agriculture. We are very much grateful for our Vice Chancellor, Prof.S.Srisatkunarajah for sparing of your valuable time to honour us by being our Chief Guest for this conference. The success of this conference depends ultimately on many people who have worked together with us in planning and organizing this event. I am very much grateful to the eclectic group of keynote speakers and researchers who will enrich the conference with their knowledge and expertise. I am truly grateful to the reviewers for their efforts in reviewing of the research papers submitted for this conference. Their untiring support has been instrumental in maintaining the quality of the conference to the highest of standards. I gratefully acknowledge the sponsors of this conference. The conference is mainly supported financially by WaSo-Asia project funded by Norwegian Agency for Development Cooperation (Norad) through Norwegian programme for capacity development in higher education and research for development (NORHED) programme. I greatly acknowledge Hemsons International (Pte) Ltd and E.S.P. Nagaratnam for their generous financial support. I am very much thankful to the dean, members of the organizing committee, chairpersons of the sessions and the numerous volunteers for their generous contribution. I welcome you all to the ICDA 2020 and wish you to have a good day!

Message from the Finance Chair

Dr.S.Vasantharuba
Department of Agricultural Chemistry
Faculty of Agriculture
University of Jaffna
Sri Lanka

I am privileged to deliver the finance chair's message to the proceedings of the 6th International Conference on Dry Zone Agriculture (ICDA 2020). This year ICDA 2020 will be hosted on 3rd December 2020, which is a coincident marking the date of the thirtieth anniversary of our faculty. Faculty of Agriculture was inaugurated on 3rd December 1990 by the former vice-chancellor, Late Prof.A.Thurairajah in Kilinochchi. ICDA started five years ago in commemoration with the silver jubilee year of our faculty. Since its inception, ICDA becomes an important event of the faculty's academic calendar. After having five conferences annually, now we are hosting the sixth in this year under the theme of "Resilient Agriculture to Cope with Unforeseen Crisis" which is more suited to the current crisis around the world.

This event would not have been a success without the generous support of our sponsors. It is my duty to express my sincere thanks to our main sponsor, WaSo-Asia project funded by Norwegian Agency for Development Cooperation (Norad) through Norwegian programme for capacity development in higher education and research for development (NORHED) programme, who has been supporting our ICDA for the third successive year. I also would like to thank other sponsors Hemsons International (Pte) Ltd and E.S.P. Nagaratnam for their generous contribution to the ICDA 2020. We deeply appreciate your willingness to sponsor this conference and make this ICDA 2020 a successful one. We sincerely hope this association will be maintained and that you will continue to support our future endeavours as well.

Finally, I would like to thank everyone who supported us to organize this conference under difficult circumstances and make it a successful one.

Message from the Joint Secretaries

Mrs. S. Selvaskanthan
Department of Agronomy
Faculty of Agriculture
University of Jaffna
Sri Lanka

Mr. S. Thatchaneshkanth
Department of Animal Science
Faculty of Agriculture
University of Jaffna
Sri Lanka

It gives us immense pleasure to write a message for the 6th International Conference on Dry Zone Agriculture (ICDA 2020), being held at Faculty of Agriculture, University of Jaffna, Ariviyal Nagar, Kilinochchi, Sri Lanka. We would like to take this message as an opportunity to welcome warmly, all the delegates to ICDA 2020.

With five successful consecutive annual symposia at the Faculty of Agriculture, University of Jaffna, the International Conference on Dry Zone Agriculture (ICDA) has become a popular forum among researchers and scholars from different disciplines across Sri Lanka and the neighboring countries, to disseminate their research findings and solutions to problems and to share ideas and experiences into emerging challenges. The theme "Resilient Agriculture to Cope with Unforeseen Crisis" is a timely topic, well suits current situation, where agricultural production is affected by many changes in its climatic, environmental and economic contexts. As university academics and researchers, we are so much committed to produce, analyze and disseminate new inventions for farming communities and ensure meeting the sustainable development goals during unforeseen crisis.

We are truly grateful to the authors who expressed interest and submitted their findings. We greatly appreciate the reviewers for their efforts in reviewing abstracts submitted for this conference despite their busy schedule. This event would not have been a reality without the commitment of the academic and non- academic staff, and the students of Faculty of Agriculture. Our special thanks goes to financial contributors and donors. We hope that this symposium will contribute sustainable improvement in the agricultural sector. We wish all the presenters and participants for a successful and productive experience.

KEYNOTE ADDRESSES

Agricultural Biodiversity for Food and Nutrition

Dr. W.L.G. Samarasinghe
Additional Secretary
(Agriculture Development)
Ministry of Agriculture
Sri Lanka

Sri Lanka is a country with a rich agro-biodiversity consisting vast array of cultivated and wild species landraces and traditional varieties that, if made available and utilized effectively, can contribute significantly towards food and nutrition security of the country. In the past, livelihoods were entangled with surrounding biodiversity to ensure food security. All the human needs were catered from sustainable use of biodiversity. With globalization and green revolution since 1970s, monocropping stands with low agricultural biodiversity was enhanced for cultivation representing very small portion of what is available in nature. Mainly nine agricultural food crops supply over 75 percent of plant derived energy intake yet three crops, wheat, rice and maize account for more than 50% being focused for cultivation in mass amounts around the world in existing arable lands available for agriculture. This has reduced the agricultural biodiversity, variable nutrition and mineral uptake, feeding the population with monotonous diets.

Monotonous agriculture have resulted in unsustainable and unbalanced food system. Even though present agriculture have achieved significant crop yields, through intensified farming in last few decades, over 800 million people still go to bed hungry every night while many more suffer from malnutrition which includes stunting and wasting, underweight and deficiencies in vitamins and minerals. As a country these failures were mainly occurred due to unbalanced supply of nutrients with fewer intakes of essential micronutrients in daily diets. According to the global nutrition report, Sri Lanka still experience a malnutrition burden among its under-five population. As a country we still lag with progress in under five wasting and overweight even though stunting shows some progress during the past years. Sri Lanka ranked 66th in the 2019 Global Hunger Index with a score of 17.1 where people suffers from a moderate level of hunger. Iron deficiency is also prominent. These statistics displays a nutritionally poor nation as a country. All these nutritional statistics gives an alarm for better integration of nutritious food in to daily diets which is vital to combat the prevailing situation.

With the intensified agriculture, agricultural biodiversity and habitats were increasingly degraded. Native crop species with beneficial traits with rich

nutritional status are also rapidly disappearing. Thus present day handful amount of agricultural crops derived food and nutrition have failed to fulfill the nutritional requirement of the populations seriously affecting the health and wellbeing as indicated above. Mainstreaming agro biodiversity towards food security is a timely need and in year 2015, Sri Lanka benefitted with FAO and UNEP funded project under Bioversity International, Biodiversity for Food and Nutrition (BFN) project. The aim of implementing the project was to mainstream agrobiodiversity towards food and nutritional security through conservation and sustainable use of agro biodiversity.

According to FAO, agricultural production must increase by an estimated 70% to feed the projected world population of 9 billion by 2050. This has to only be achieved together maintaining agro biodiversity and increasing the agricultural productivity by the key stake holders in agricultural sector. Preserving agricultural biodiversity preserves indigenous knowledge associated with biodiversity, germplasm and landraces, useful genetic resources with diversified important traits. Agro biodiversity with the diversity of crops can also adapt and support in mitigating the climate change. Sri Lanka is a country identified with high degree of biological diversity and issues related to nutritional imbalances and inculcating healthy dietary patterns can only be tackled with sustainable food systems derived from local agro biodiversity. Utilization of the existing agro biodiversity can be achieved by home garden diversifications through local agro biodiverse food crops, characterization of nutrition profiles of these crops through food composition analysis, creating healthy and sustainable diets utilizing local agro biodiversity while increasing awareness of the population.

It has been showed that traditional rice varieties are rich in iron and vitamin K content. Among the studied leafy vegetables, green thampala showed highest iron content giving insights to cater these crop species for daily diets to enhance the nutritional status. Traditional knowledge among the villagers regarding these species and their various benefits cannot be neglected and these knowledge was also preserved and documented through several book publications such as, Local yams diversity and health benefits, Dishes prepared from local yams, Hela Ahara Wattoru etc. Raising awareness among the population regarding the use of local agro biodiversity towards food and nutrition is a must. Food festivals, Field diversity and food fairs, Agro biodiversity symposiums, Home garden diversifications, school home gardens, quiz competitions for school children are some of the activities conducted to bring up the topic into the limelight. Similar strategies needed to widen the access of these agro biodiversity derived products to the general public. “Hela Bojun” outlets under the Department of Agriculture occupy these traditional agrobiodiverse crop plants derived food items for sale towards the community. These outlets are enhanced with food items derived from traditional local food

crops, displaying the nutritional facts of the food items together with traditional crop species for purchasing. Evidence and associated traditional knowledge gathered together exhibited the rich agricultural biodiversity and its importance existing within our country.

The treasure of local food system enriched with local agro biodiversity must be conserved while it's sustainable utilization to fulfill the nutritional requirements of the population. Ensuring agriculture biodiversity and nutrition remain central point in addressing the hunger and malnutrition prevalence thus as a nation, sustainable utilization of local agro biodiversity is a timely need to combat the burdening issues while adapting conservation tactics to preserve local agro biodiversity.

Tree-based Agriculture to Enhance Resilience under Changing Climates

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Associate Professor
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Agroforestry is an approach to land-use that incorporates trees into farming systems (tree-based agriculture), and allows for the production of trees, crops and/ or livestock from the same piece of land to obtain economic, ecological, environmental and cultural benefits. In the recent past, agroforestry technologies are being promoted as climate resilient land-use systems by global organizations such as Food and Agriculture Organization (FAO), United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). This is mainly due to the resilience shown by the perennial tree component under dryland conditions in relation to potential microclimatic modifications, bio-physical interactions, enhanced biodiversity and ecosystem services to mention a few. In relation to Sustainable Development Goals (SDGs), it is believed that multi-functional ecosystems are needed and have to be created in arid and semi-arid regions of the world as one of the strategies to achieve the first two SDGs by 2030; no poverty and zero hunger among resource-poor rural communities (close to 1.3 billion people). In this context, FAO has conducted significant volume of work to document 'trees outside the forest'. It has been revealed that trees in forest are declining but trees outside the forest are increasing in the 11% of the global arable land area. About 1 billion hectares (ha) of agricultural lands out of 1.5 billion ha of world's crop lands now have trees on them (FAO 2005).

For example, in many parts of world's dry areas (African continent, arid areas of India, Israel, Morocco, Turkey, China) to overcome climate extremes resulting from climate change, trees and shrubs are combined with agricultural crops. This combination of perennials with annual crops and livestock has resulted in increased soil fertility, crop and tree productivity, has met energy needs, supplied fodder for livestock and thereby contributed to enhanced household income and food security (Krishnamurthy et al. 2019).

The science supporting the above outcomes has been well-established. Interactions between the perennial and the annual component in agroforestry systems are defined as the effect of one component of the system on the performance of another

component and/or the overall system (Nair 1993). The study of interactions requires the examination of a number of complex processes related to soil fertility, competition, microclimate, insect pests and diseases, soil conservation and allelopathy (Rao et al. 1998). Enhancing positive interactions between the woody (tree) and non-woody (agricultural or annual crop) components and the minimization of negative interactions through proper management strategies is the key to the success of tree-based agricultural systems for the arid and semi-arid regions of the world, especially under changing climates (Thevathasan and Gordon 2004).

Results from a long-term (33 years) tree-based agricultural system in relation to above interactions and management strategies are discussed in the keynote presentation. Agroforestry is not the only solution to solve environmental, ecological, economic and social problems of communities living in arid and semi-arid regions of the world. It should be noted that the adoption of such land-use systems by landowners is challenged by many factors, to list a few, lack of policy incentives, lack of proper institutional arrangements, ecosystem services derived by this land-use often not recognized and rewarded and landowners are reluctant to invest due to the time lag between adoption and income generation. These challenges need to be addressed to enhance the adoption of tree-based agriculture in the arid and semi-arid regions of the world.

REFERENCES

FAO. 2005. Report on State of the World's Forests.

Krishnamurthy L., Krishna Krishnamurthy P., Rajagopal I. and Solares A.P. 2019. Can agroforestry systems thrive in the drylands? Characteristics of successful agroforestry systems in the arid and semi-arid regions of Latin America. Agroforestry Systems 93:503-513

Nair P.K.R. 1993. An Introduction to Agroforestry. Kluwer Academic Publishers, the Netherlands, pp 499.

Rao M.R., Nair P.K.R. and Ong C.K. 1998. Biophysical interactions in tropical agroforestry systems. Agroforestry Systems 38: 3–50.

Thevathasan, N. V. and Gordon A.M. 2004. Ecology of tree intercropping systems North temperate region: Experiences from southern Ontario, Canada. Agroforestry Systems 61: 257-268.

Developing Climate Resilient Banana Industry

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INTRODUCTION

Abiotic stress can be termed as the negative impact of environmental factors on the organisms in a specific situation. With the international banana trade of more than US$45 billion, banana has a huge impact on the economy of many countries (Brown et al. 2020). In India, banana as an enterprise is generating around $7 billion and providing livelihood to millions of farmers. India contributes 21% world banana production with the production of 31.74million tons in an area of 8.98 lakh hectares. Changing climate, influence the banana production and become a greater menace to the extent of wiping out the industry. In this chapter, an effort has been made to link the impact of future climate on various atmosphere related abiotic stresses and possible management options to counter their negative impacts in banana (Uma and Kumar 2020). The banana cultivation once considered to be the profitable and the tool to enhance the farmers income manifold become victim of monsoon failure, depleting natural resources, poor adaptation of sustainable agricultural technologies and emergence of new insect pests like scarring beetle, skipper butterfly and the threatening diseases like Fusarium wilt with new Tropical Race 4 which affects all the clones of banana including Cavendish group. With the increasing temperature, the demand for water is also increases which are projected to increase by 12-15% (Calberto et al. 2015).

INFLUENCE OF ABIOTIC STRESSORS ON BANANA

Moisture and temperature

Water stress refers to the situation where cells and tissues are less than truly turgid. It occurs whenever the loss of water in transpiration exceeds the rate of absorption. Higher evapo-transpiration rates, elicited by rising temperatures, are likely to exacerbate an already tenuous situation where irrigation is viewed as a major limitation to production (Kumar et al. 2014). The banana plants need continuous sources of soil moisture for optimum growth as transpiration loss is estimated at 30–60 m^3. Any water deficit would thus retard its growth and the effects may sometimes be evident only several months after the drought (Hoffmann and Turner, 1993). Plants respond to dehydration stress by synthesis of protective proteins like

chaperones, LEA proteins, dehydrins, aquaporins etc. and by the degradation of irreversibly damaged proteins by proteases. While the influence of temperatures is likely genotype specific, locations with temperatures expected to exceed these upper limits (>35 °C) for extended periods of time could become unsuitable for banana production (Calberto et al. 2015; Bal et al. 2018). Leaf emergence stops below 10°C temperature. During the summer, each plant may produce 4 or 5 leaves a month, but in the winter, only about half a leaf a month (Turner 2007) is produced. Skin splitting could be associated with temperature aberrations coupled with fluctuation in moisture.

Hailstorm

The development of hailstones typically occurs 5 to 7 km/h above the earth's surface. As a thunderstorm moves along, it may deposit its hail in a long narrow band (often several kilometers wide and about 5-10 km long) known as a hail-streak or hail-swath. Its size and shape depend on how fast the storm is moving and how strong the updrafts are inside the storm (Bal et al. 2018).

Frost

Frost occurs when water vapour in the air freezes upon contact with an object that has a surface temperature below 0 °C. Sub zero temperature has the capability to make irreversible changes within two minutes while it takes 3 days at 8 °C and 10 min at 0 °C. Drought years are conducive to radiant frost due to the lack of cloud cover and the increased difference between day and night time temperatures. When plant tissues freeze, ice crystals form and rupture cell walls.

Rainfall

Banana requires irrigation fortnight interval during its growth when there is no rainfall (Ravi et al. 2013). Fairly good soil drainage is known to be an essential condition which favours growth of the banana crop. Continuous water logging for two days makes the plants to be stunted whereas further water logging leads to death of plants.

Salinity

The coastal system, made up of waters from the sea and other estuaries. As a result, precipitation, evaporation, wind events, and direct inflows of fresh water through stream flow and runoff, strongly influence the salinity, water quality, and circulation of coastal waters. Banana is highly susceptible to salt accumulation and many traditional banana growing areas are affected with this phenomenon and irreversibly affect the banana growth and yield.

TECHNOLOGIES FOR CLIMATE CHANGE MITIGATION & ADAPTATION

Banana Leaves: Role in Climate Resilience

Banana leaves produce an epicuticular wax that may play a role in resistance to biotic pests as well as providing drought tolerance. Epicuticular waxes serve to limit non-stomatal water loss and were found to be positively correlated to leaf water retention capacity in banana (Carpentier et al. 2007). The folding of banana leaves is influenced by water status, but laminae will fold even in well-irrigated plants as this reduces photochemical damage during the day caused by higher photon flux density. Besides, tearing of leaves may increase the cooling effects of wind under hot dry conditions and could be associated with increased leaf water efficiency.

New Traits and Varieties

Breeding programmes based on ploidy manipulation have resulted in the successful development of new disease-resistant plantain and cooking banana hybrids (Muthusamy et al. 2014). Over the years of breeding resulted into the release of different banana varieties across various states from different institutes. CO1 from TNAU; BRS 1 (Agniswar x Pisang lilin), BRS 2 (Vannan x Pisang Lilin) from BRS, Kannara, KAU; Udayam, Kaveri Saba (drought and salinity resistant), Kaveri Kalki (wind resistant), Kaveri Sugantham, Kaveri Haritha and Kaveri Kanya from ICAR-NRC Banana. Mutants were selected in Rasthali and Grand Naine to evolve the lines for dwarfness, shorter crop duration, high yield and resistance to diseases (Saraswathi et al. 2016).

Use of Molecular Probes for Marker-Assisted Breeding

Metabolic profiling of plants under stress is an important tool to study stress-induced changes in metabolites (Ravi et al. 2013). As tolerance to stress is multifactorial syndrome rather than result of a single reaction or gene tackling of the primary stress reactions by gene transfer can also alleviate the secondary stress and generate plant with higher stress tolerance (Carpentier 2008). There are a large number of genes and proteins associated with stress tolerance in plants and so the best approach to identifying stress tolerant lines is apply the stress of interest and perform quantitative trait loci (QTL) analyses (Uma et al. 2004).

Production Systems and Operations

Some of the basic methods to collect and conserve water are; harvesting of rain water, development of catchment area and storing runoff water for recycling, check dams and construction of waterways. Crop rotation, cover crops, strip cropping, mulching, contour hedge row intercropping system, contouring, contour bunds, sloping area land technology (SALT), contour drains, graded bunding, terraces, broad bed furrow system for raising crop and conservation of water, contour furrow, stabilisation structures, soil conservation and water retention through use of vegetation, and loose boulders are some of the other agronomical measures used to

conserve moisture (Uma and Suresh Kumar 2020). Through drip irrigation replenishment of evaporation up to 80% is optimum to get higher yield. ICAR-NRC for Banana has developed a technology on Fertilizer Tailoring Equations (FTEs) for optimizing the fertilizer requirement to increase the productivity for banana. Wind breaks deflect and filter through the wind current thereby reducing the velocity of wind leading to lower displacement of wind around tree and cause reduction in transpiration and evaporation. Drip fertigation system economizes the use of fertilizers and water ranging from 40 to 60 %. Fertilizer use efficiency was increased up to 67 % over conventional fertilizer application. Foliar application of 0.1 mM acetyl salicylic acid before imposing soil water deficit stress at critical stages produced normal bunch without malformation (Ravi et al. 2013). Several anti-transpirants are successfully used like Acropyl, polycot and Kaolinite in banana. De-naveling of male bud and pre-harvest spraying of bunches with 2.0% Potassium sulphate solution (20g /litre of water) first immediately after the emergence of the last hand followed by a second spray 30 days later and covering the bunches with 100 gauge thick non-woven polypropylene bags resulted into better bunches with uniform finger filling. Foliar sprays of 50 mM IAA, GA3, or benzyl aminopurine (BAP) partially counteracted the effect of water deficit on photosynthesis and transpiration. Accelerated ripening or senescence is most often mediated by ethylene production in response to the stress. As consequence anti-ethylene products such as aminovinylglycine (AVG) and 1-methylcyclopropene (1-MCP) could be used to mitigate drought stress.

Conservation Agriculture

The basic principles of conservation agriculture are soil cover, particularly through retention of crop residues on the soil surface as mulch or cover crops; a minimum level of soil disturbance, e.g., reduced or zero tillage practices; and sensible, profitable crop rotations. Soil moisture can be conserved through mulching either with black polythene or locally available mulches, growing cover crops or inter-culturing in the orchards to check soil erosion and runoff rain water (Kumar et al. 2014).

Systems Biology Approach

Systems Biology approach which integrates the series of –omics i.e. phenomics, genomics, transcriptomics, proteomics, metabolomics and others is getting roots since the early new millennium (Cramer 2010). The recombinant DNA technologies like Crisper cas9 hold big promise towards the development of crop varieties tolerant to variety of the abiotic stress factors such as drought, heat, cold, salinity and others. Transcriptomic, proteomic, and metabolomic approaches have been combined with computational analysis and plant transformation to provide a wealth of information on putative candidate genes, gene families, and pathways involved in alleviating detrimental impacts of stress (Carpentier et al. 2007).

Measures to Control Biotic Stresses

The increase in insect population leads to demand for more use of pesticide, which unknowingly causes lots of harm to ecosystem as well as to human health. The pests like banana weevils, aphids may have more population in the changed environment. Soil application of B. bassiana / Lecanicillium lecanii (1×10^9 CFU /ml) at the rate of 100 ml per plant during last week of September to kill the grub and pupal stages was developed to control the fruit scarring beetle. First time, occurrence of the deadliest wilt strain, Tropical Race 4 of Fusarium oxysporum f.sp. cubense (Foc) which infects Cavendish banana cvs. Grand Naine has been confirmed in Katihar district of Bihar by ICAR- NRCB. Immunoassay based dipstick were developed for BBrMV and CMV to contain their spread based on lateral flow immunochromatography principle using specific antibodies and tested it with different infected tissues (Selvarajan et al. 2015).

Use of Beneficial Microbes

Plant growth-promoting rhizobacteria (PGPR) and fungi (mycorrhizae) can facilitate plant growth directly by facilitating the uptake of nutrients from the environment, by influencing phytohormone production (e.g. auxin, cytokinin, or giberellin), and/or by enzymatic lowering of plant ethylene levels. Rhizobacteria include mycorrhization helper bacteria (MHB) and plant growth promoting rhizobacteria (PGPR), which assist AMF to colonize the plant roots (Glick et al. 1999). These benefits of mycorrhizal symbioses in fruit tree increased growth and yield, both agronomically as well as ecologically by improved fitness, indicate that mycorrhizal plants are often more competitive and better able to tolerate environmental stresses (Turner et al. 2007).

Use of Mechanization in Agriculture during Extreme Weather Events

One protection method is to use wind machines in orchards of high value crops. Wind machines are tall, fixed-in-place, engine-driven fans that pull warm air down from at least 15 m above ground during strong temperature inversions, blowing it down and out, pushing away and replacing cold air near target crops. Protective screens termed as anti-hail nets above the crop can be appropriately utilised especially for high value crops (Suresh Kumar et al. 2017). Tree shelterbelts can markedly reduce hail damage in their immediate vicinity since hails are usually associated with strong winds (Bal et al. 2018).

Innovative and Improved Postharvest Management Strategies

As climates become hotter and precipitation more erratic, the potential for postharvest losses may increase and thus improved transport and storage become even more important. Simple modifications to postharvest handling systems can sometimes result in significant reduction in stress exposure and consequently result in storage and/or shelf life extension. One of the most successful strategies is the application of plastic film packaging or wraps to prevent desiccation, resulting in

significant improvements and shelf life and quality of banana. Modified atmospheric packaging totally revolutionized the way with which banana is transported.

FUTURE PERSPECTIVES

Developing methodologies based on input-output models which provide information about the cluster wise production of banana and could identify the major catchments for supplying the fresh produces. Using AI/ IoT/ App based platforms to provide and generate real time data points and to reduce climate vagaries.

Disseminating the climate resilient, sustainable scientific agro-techniques with the integration of hi-tech plant and bunch care management along with the yield targeted nutrient dynamics and eco-system based resilient, sustainable pest and disease management solutions.

Development and validation of IDM practices (consortia of bio-agents, chemicals, botanicals, crop rotation, host resistance etc), bio-priming methods through multi-location trials in hot spot area of Foc–TR4. Host pathogen interaction and micro biome studies to find out the genes/microbes/chem¬icals involved in resistance to Fusarium wilt disease and other diseases like leaf spot and postharvest diseases. Developing on-site detection kits based on lateral flow immuno-assay as well as lateral flow Nucleic acid assay.

Policies and institutions that promote economic development and reduce poverty will often improve agricultural adaptation and may also pave the way for more effective climate change mitigation through agriculture.

CONCLUSION

Concerns about mitigating and adapting to climate change are now renewing the impetus for investments in agricultural research and are emerging as additional innovation priorities. Breeding efforts to improve banana will need to address these disruptions to production and food security by placing a greater emphasis on identifying sources of genetic stock material adapted to warmer and drier climates and, while at the same time, taking advantage of genomic approaches and molecular techniques recently utilized with successful outcomes in other crop species. In addition, due to limited resources, a prioritization of the various threats of climate-induced challenges to banana production which in turn needs to be integrated into a long-term breeding strategy of overall crop resilience. Anticipatory adaptation is also important with respect to major capital investments by producers and the agri-food industry. In the coming decades, the development and effective diffusion of new agricultural technologies will largely shape how and how well farmers mitigate and adapt to climate change.

REFERENCES

Bal S.K., Suresh Kumar P., Singh Y., More N., Minhas P.S. 2018. Managing Atmospheric Stressors' Forced Challenges in Agriculture under Future Climate. In: Manish Bhan et al. (Eds.), Climate Resilient Agriculture: Adaptation and Mitigation Strategies @ New India Publishing Agency, New Delhi pp.51-75

Brown A., Carpentier S.C., Swennen R. 2020. Breeding Climate-Resilient Bananas. In: Kole C. (eds) Genomic Designing of Climate-Smart Fruit Crops. Springer, Cham. https://doi.org/10.1007/978-3-319-97946-5_4

Calberto G., Staver C., Siles P. 2015. An assessment of global banana production and suitability under climate change scenarios. In: Elbehri A (ed) Climate change and food systems: Global assessments and implications for food security and trade. Food Agriculture Organization of the United Nations (FAO), Rome

Carpentier S.C., Witters E., Laukens K., Van Onckelen H., Swennen R., Panis B. 2007. Banana (*Musa* spp.) as a model to study the meristem proteome: acclimation to osmotic stress. Proteomics 7:92–105

Freeman B., Turner D. .1985. The epicuticular waxes on the organs of different varieties of banana (*Musa* spp.) differ in form, chemistry and concentration. Aust. J. Bot. 33:393–408

Glick B.R., Patten C.L., Holguin G. et al. 1999. Biochemical and genetic mechanisms used by plant growth promoting bacteria. Imperial College Press, London, p267

Hoffmann H.P., Turner D.W. 1993. Soil water deficits reduce the elongation rate of emerging banana leaves but the night/day elongation ratio remains unchanged. Sci Hortic 54:1–12

Kumar P.S., Minhas P.S., Govindasamy V., Choudhary R.L. 2014. Influence of Moisture Stress on Growth, Development, Physiological Process and Quality of Fruits and Vegetables and Its Management Strategies.In (Eds. R.K. Gaur and Pradeep Sharma) Approaches to Plant Stress and their Management, Springer publications., New Delhi, pp.125-148

Muthusamy M., Uma S., Backiyarani S., Saraswathi M.S. 2014. Computational prediction, identification, and expression profiling of microRNAs in banana (Musa spp.) during soil moisture deficit stress. J. Hortic. Sci. Biotechnol. 89:208–214

Ravi I., Mustaffa M.M. 2013. Impact, Adaptation and Mitigation Strategies for Climate Resilient Banana Production. In Climate-Resilient Horticulture: Adaptation and

Mitigation Strategies. Eds. Singh HP, Srinivasa Rao NK and Shivashankara KS. Springer India 2013. ISBN 978-81-322-0973-7. pp 45-52

Saraswathi M. S., Kannan G., Uma S., Thangavelu R., Backiyarani S. 2016. Improvement of banana cv. Rasthali against FoC (VCG 0124/5) through induced mutagenesis: Determination of LD50 specific to mutagen, explants, toxins and in vitro and in vivo screening for Fusarium wilt resistance. Ind. J. Exp. Biol. 54: 345 – 353

Selvarajan R., Balasubramanian V., Sasireka T. 2015. A simple, rapid and solvent free nucleic acid extraction protocol for detection of banana bunchy top virus by polymerase chain reaction and loop-mediated isothermal amplification. Eur J. Plant Pathol.142:389-396

Suresh Kumar P., Bal S.K., Singh Y., Choudhary V.K., Sangeetha A., Kanwat M. 2017. Abiotic stresses forced challenges in agriculture under future climate. In. Climate Change and Sustainable Agriculture (Eds. Suresh Kumar P, Kanwat M, Meena PD, Vinod Kumar and Alone RA.). New India Publishing Academy, New Delhi. pp. 1-26

Thangavelu R., Mostert D., Gopi M., Ganga Devi P., Padmanaban B., Molina A. B., Viljoen A. 2019. First detection of *Fusarium oxysporum* f. sp. cubense tropical race 4 (TR4) on Cavendish banana in India. Eur J. Plant Pathol. 154 (3):777-786. https://doi.org/10.1007/s10658-019-01701-6

Turner D.W., Fortescue J.A., Thomas D.S. 2007. Environmental physiology of the bananas (*Musa* spp.). Braz. J. Plant Physiol. 19:463–484

Uma S., Suresh Kumar P. 2020. Banana research and development in India-Challenges and opportunities. Progressive Horticulture, 52 (1): 1-11

Uma S., Sudha J., Saraswathi M.S., Manickavasagam M., Selvarajan R., Durai P., Sathiamoorthy, S., Siva S.A., 2004. Analysis of genetic diversity and phylogenetic relationships among indigenous and exotic Silk (AAB) group of bananas using RAPD markers. J. Hortl. Sci. Biotech. 79(4): 523-527

More Milk for All: Shifting Horizon for Sustainable Dairy Production in Dry Zone of Sri Lanka

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The dairy sector is a part of the agriculture sector, which is focusing on the production of fresh milk and value added products. The dairy farming sector in Sri Lanka is dominated by smallholder subsistence farmers and 75% of local milk production comes from them. Approximately, 72,400 families depend solely on dairy as their main source of income and majority of them are inhabitants in the Eastern and Northern Provinces of Sri Lanka. In 2019, the estimated total national milk production was 424.1 million liters, of which the cow milk and buffalo milk accounted for 356.6 million liters, and 67.5 million liters, respectively. The average farm gate price of milk was LKR. 70.83 per liter in 2019. The national milk consumption requirement is approximately 1,200 million litres per annum, equivalent to 54 litres per annum per capita consumption. Despite many recent developments in the dairy industry, the total milk production is able to fulfil only around 45% of the total milk requirement of the country at present. In order to bridge the gap between the total demand and supply for milk, the country annually imports milk powder and dairy products spending colossal amount of money. In 2019, 98,838 MT of milk and milk products were imported with the value of LKR. 55,646,632,137. Over the years, the imported quantities as well as the cost of imports have grown by 6.3%.

Sri Lankan government has understood the importance of ensuring self-sufficiency in milk while overcoming the pressures from internal and external challenges. Therefore, it is important to identify the existing gaps and introduce appropriate measures and interventions for sustainable self-sufficiency of milk within the country. The majority of dairy farms in the dry zone are managed under extensive system, where the availability of drinking water and quality feed is seasonal and experience severe shortages of feed during dry seasons. In this regard unlocking the potential of establishing and managing rainfall based appropriate high quality forages and conservation methods would be paramount important. Other appropriate nutritional strategies should be adopted along with proper interventions for improving feed resources both quantitatively and qualitatively to address the current issues related to feed scarcity, abrupt change of nutrition/feeds and non-

availability of good quality forages. One of the major constraints in smallholder dairy productivity is inadequate supply of drinking water, especially during the night. Often the cows are shortage in supply of drinking water. Moreover, strategic actions such as genetic upgrading of indigenous animals using exotic semen, implementation of efficient artificial insemination service throughout the area, progeny testing of bull-calves for natural breeding, securing investments from the private sector, provision of institutional support such as irrigation for forage crops and soft loans, establishing favourable farm gate price for raw milk, establishment of new silage making and dairy processing plants and expanding and modernization of the existing dairy processing plants could be considered as interventions for increasing the milk production in dry zone of Sri Lanka. Last but not least, reform is needed for greater dairy policy coherence and capacity building programmes play an important role in improving quality and quantity of milk production in the dry zone of Sri Lanka.

Sustainable Pulse Production through Integrated Crop Management Practices

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Pulses are an integral part of Indian agricultural economy next to cereals and oilseeds in terms of acreage, production and economic value. Pulses have excellent source of high quality protein, essential amino acids, fatty acids, minerals and vitamins for millions of Indians. India is the largest producer and consumer of pulses in the world. Nutritional scientist in recent years have not recommended intake of large amounts of protein of animal origin. They have stressed the value of grain legume as source of protein and fiber. Pulses production has been stagnant at between 11 and 14 million tonnes over the last three decades. Per capita pulses consumption over the years has come down from 61 g/day in 1951 to 35 g/day in 2015. The ability of pulses to fix atmospheric nitrogen (Subbarao 1988) in the soil-crop system is their unique and beneficial characteristics among all plant species.

Most of the pulses have an enormous potential for cultivation because of their short duration nature, N fixing capacity and adjustability under different cropping systems/situations. However for the present, these desirable characteristics of pulses could not be exploited or capitalized for some reasons. In spite of many beneficial effects, pulses are still considered as secondary crop with respect to management. In India, these crops are largely cultivated under energy starved conditions resulting in poor pulse productivity. This is mainly because of non-availability of quality seed at desired time, imbalanced use of fertilizers and nonadoption of improved crop management practices. Pulses are grown on marginal and degraded land over the years with low or no inputs. Conservation practices have shown advantages over traditional practices by means of improving productivity and soil health (Ali and Venkatesh 2009) in many parts of world. More recently, under the National Food Security Mission (NFSM), Ministry of Agriculture, Goverment of India has been given high priority to increasing the productivity of pulses across the country to curtail growing imports, reduce protein malnutrition and make pulses affordable to the common man.

Integrated crop management (ICM) is a holistic approach to the sustainable production of pulses. It considers the most suitable and safe approach for long –term benefit. Various agronomic researches have shown that integrated crop management practices, such as soil management, seed replacement with improved varieties, raised bed planting method, use of biofertilizers, crop diversification, foliar application of fertilizers at critical stages, watermanagement, application of secondary and micro-nutrients and adoption of integrated weed and pest management, etc. have great potential in gearing–up pulses productivity.

The key challenge today is to adopt proper integrated crop management strategies that will address the dual concerns of maintaining and enhancing the sustainability of the natural resources and improved productivity of pulses. In this paper, an attempt has been made to discuss the integrated crop management practices which can play a vital role in sustainable pulse production in India

INTEGRATED CROP MANAGEMENT PRACTICES

Improved Varieties

Crop productivity at a given location depends on the potential of the genotype used. For increasing over all production of pulses in the country, it may be necessary to use several regionally and seasonally adopted cultivars. The best quality of seeds play major role in production and productivity of pulses.

Sowing Date

Date of sowing plays a major role in the crop production. The time of sowing is an important non-monetary input to achieve synchronous maturity and higher productivity of pulses. The optimum time is mainly dependent on prevailing agroclimatic conditions of an area besides variety sown.

Rice Fallow

Most of the farmers in south India pulses are grown in rice fallow condition. The timely sowing of pulses is crucial in view of the moisture deficit during critical periods in the rice fallow conditions. The farmers usually broadcast the seeds to take advantage of residual moisture in rice fallow situation .

Irrigation

Generally the pulses are grown as fallow crop, inter crop, rainfed crop, mixed crop bund crop and border crop. In a pure crop under irrigated condition irrigation plays vital role that is optimum supply of water will enhance the growth and yield components of pulses. Excess irrigation may affect the crop growth because these group of crops more sensitive to water stagnation.

Crop Diversification

Crop diversification provides the farmers with a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to bring down the possible risk. Crop diversification in India is generally viewed as a shift from traditionally grown less remunerative crops to more remunerative crops. In water scarcity areas instead of keeping the field as fallow we can grow short duration pulses as an alternative crop with the available moisture.

Integrated Cropping Systems

Pulses in the cereal/oilseed based cropping systems are introduced to break the monotony of crop rotation. Apart from enriching soil fertility, introduction of pulses in cropping system also improves nitrogen economy.

Addition pulses to a cropping system can enhance total productivity of all crops by rising the availability of nitrogen and other mineral nutrients, disrupting pest, weed, and disease cycles, enhancing nutrient and water use efficiency. Short duration pulses grown as inter crop, mixed crop, border crop and bund crop

Foliar Nutrients

Main reason for low productivity is due to decreasing soil fertility and imbalanced use of fertilizer. Lack of nutrients during the critical stages of crop growth leads to nutrient stress, poor growth and productivity were found to be some of the yield barriers of pulse crop (Abrol et al. 1999). To overcome these constraints, additional nutrition through foliar feeding is play a vital role in pulse production by stimulating root development, nodulation, energy transformation, various metabolic processes and increasing pod setting and thereby increasing the yield. This is one of the most efficient ways of supplying essential nutrients to a growing crop.

Postharvest Technology

The crop should be harvested at appropriate time based on the duration and maturity symptoms. Delay in harvest leads to dropping of grains in the field itself then it is very difficult to collect the grains from the field. Early harvest results in immature pod with high moisture leads in spoilage of grains. Storage of pulses' grains is prone to damage due to storage grain pests causing huge economic losses in comparison to split ones (in form of dal). Value addition certainly ensures more money from farm produce to the farmers.

The above mentioned Integrated Crop management (ICM) practices are observed to be appropriate agro-tecniques for augmenting the productivity and profitability of pulses without affecting the soil fertility and soil health. Further these techniques hold promise as an eco-friendly and low cost technology in pulse production in a sustainable manner.

REFERENCES

Abrol I.P. 1999. Sustaining Rice-Wheat system productivity in Indo-Gangatic plains: water management related issues. Agricultural Water Management 40, 31-35.

Ali M., Venkatesh, M.S. 2009. Pulses in improving soil health. Indian farming 58 (11) : 18-22

Subbarao N. S. 1988. Biological nitrogen fixation: Recent developments. Oxford and IBH publication. pp. 1-19

ABSTRACTS

Agricultural Economics and Agribusiness Management

Analysis of Resource Use Efficiency in Chilli Production and Its Contribution to Household Farm Income in Manmunai South and Eruvilpattu DS Divisions, Batticaloa

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Chilli is one of the major cash crops grown in Sri Lanka. The resource use efficiency in chilli production has a significant contribution to household income. Technical efficiency is determined by several efficiencies and inefficiency variables. The major objective of this study was to analyse the resource use efficiency and its contribution to household farm income in Manmunai South and Eruvilpattu DS divisions. Quantity of urea, NPK, organic fertilizer and pesticides and method of irrigation were included as explanatory variables in the production function. Age of farmer, education, involvement, experience, extension services and the number of plants in the field were considered as the factors for the inefficiency of chilli production. Descriptive statistics, and Cobb Douglas stochastic frontier production function were used to analyse data. The result of this study shows that, in Cobb Douglas production function, the coefficient of urea (0.1) is positive and significant. It indicates that if the quantities of urea per plant increase by 1%, it increases the yield of green chilli per plant by 0.1% while other things equal. In the inefficiency model, the number of plants in the farm was positive and significant. The coefficient of number of plants indicates that number of plants in the farm increases by 1000 units, the inefficiency of the farm increases by 2%. The average technical efficiency of chilli production in this study area is around 81%. Variations in the efficiency of chilli productivity in the farms were around 81%. Therefore, there is high potential to increase the efficiency in chilli production by 19% with available current technology. This study indicates that small chilli farms are more efficient than large chilli farms. Therefore, Department of Agriculture should provide materials and technical assistance to small farms to increase the efficiency and total chilli production in this study area.

Keywords: Chilli, Inefficiency, Productivity, Resource use efficiency

Identification of the Potential to Introduce Mobile Based-Demand and Supply Forecasting System for Potato Farmers: A Case in Nuwara Eliya District

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In Sri Lanka, potato farmers commonly face uncertainties regarding supply and demand. Therefore, most of the farmers used to take their decisions based on the rough measurements, or informal/formal recommendations. This leads to occur over-supply resulting food wastage and price dropdown. To overcome this situation, this study was conducted to identify the potential on providing future demand and supply information through mobile-based information system in planning stage. This research study was conducted in Nuwara Eliya district by selecting 50 potato farmers using Snowballed sampling method. Then, selected farmers' willingness was captured by using pretested questionnaire. Collected data were analyzed by using one-way ANOVA. According to the results of one- way ANOVA, age of the farmers (p= 0.05), gender (p = 0.05) and education level (p= 0.000) showed the strong significant relationship with willingness to have mobile-based demand and supply forecasting system while farmers' employment status (p = 0.080) and their farming type (p = 0.068) showed the marginal significant relationship. Moreover, when comparing the mean values within the categories, 20-30 age group (Mean = 4.80) in age category, male farmers (Mean = 4.36) in gender category, farmers educated up to GCE A/L (Mean = 4.75) in education category, farmers who engaging other sectors as their full time occupation and doing part time potato farming (Mean = 4.67) in employment status category, and farmers doing contract farming (Mean = 5.00) in farming type category showed the highest mean values within the category that they belonged. Therefore, these farmers tend to have mobile-based demand and supply forecasting system for their decision-making process than the other farmers . Accordingly, there is a high potential to introduce mobile-based demand and supply forecasting system for male, educated farmers up to GCE A/L who belong to 20-30 age group, who do part time potato farming, and who engaged in contract farming at the initial stage. These findings provide promising avenues for future research related to other crops as well in this regard.

Keywords: Demand and supply, Forecasting, Mobile-based information system, Potato Farming

Technical Efficiency of Paddy Production and Factors Affecting the Efficiency in Anuradhapura District, Sri Lanka

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The study examines the technical efficiency of paddy production and factors affecting the technical efficiency of paddy production in Anuradhapura district of Sri Lanka. For this study, 165 farmers cultivated paddy in *Maha* season of 2019/20 were randomly selected. A Cobb-Douglas stochastic frontier production model was developed. The result of this study reveals that average technical efficiency of paddy production in Anuradhapura district is 81.9%. It indicates that there is a potential to increase the paddy production by 18% with currently available technology. The result shows that fertilizer, pesticides and labor have positive significant effect on paddy production. This study also shows that the extension services positively influence technical efficiency of paddy production. Thus, Department of Agriculture should increase the extension services in Anuradhapura district to increase the technical efficiency of paddy production and thereby increase total production.

Keywords: Cobb-Douglas Stochastic Frontier production, Extension Services, Technical Efficiency

Mapping and Display Paddy Production Information in Sri Lanka from 2005 to 2019: Application of GIS and Web GIS

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Crop data is very useful in terms of agriculture sector. Combination of spatial and aspatial crop data make greater awareness and more accurate knowledge in agriculture industry. New technology can be used to collect, display and analyze the crop data in decision making process. Web GIS which is a type of distributed information systems, comprising at least a server and a client, is one of the technologies that can be used to display and analyze spatial and aspatial data on the internet. Objective of this study is to use of capability of GIS and Web GIS to collect, manipulate and display the paddy data in each district of Sri Lanka for *Yala* and *Maha* seasons from 2005 to 2019. Paddy production statistics from Agriculture and Statistic Environmental Division, Department of Census and Statistics and districts data layers from Survey Department were collected as secondary data. District-wise total production of paddy collected data were entered to excel sheet with compatible format to Web GIS. After that, entered excel sheet was joined to attribute table of district shape file through Arc GIS 10.1 software. Likewise, two shape files with attribute tables were prepared to show *Yala* and *Maha* total production of paddy. After that, shape files with the attribute table were included to Web GIS and prepared it in user friendly way. Results on district-wise paddy production from 2005 to 2019 with the datasets in Sri Lanka indicate the system can effectively manage regional agriculture spatial information and show a good applicability and guidance on agriculture management. This study reveals that GIS and Web GIS support a large number of users simultaneously; it makes better cross-platform capability; it is easy to use for end users; it gives opportunity for map handling, agricultural spatial information query and analysis; it is a collaborative collection of geospatial information; it can be used for cropping system evaluation, ecological distribution of farm products, estimation of cropping potential production, visual display of results and system maintenance. However, when considering the data and information displaying and sharing, Web GIS is user friendly than Arc GIS.

Keywords: Agriculture, Arc GIS, Crop data, Paddy, Web GIS

A Study on the Instruments Preferred by Key Stakeholders to Promote Organic Fertilizer through Agri-Food Value Chains

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Consumption of organic food and agricultural products have been expanded remarkably in the recent past and the terms like 'organic agriculture / products', in general, and 'organic fertilizer' that in particularly in use to demarcate one of the key inputs utilized in such systems become increasingly popular. On the understanding that positive changes to the perceptions of stakeholders along the agri-food values chains generate such trends and a mindset, this study was focused on investigating the promotional instruments of organic fertilizer preferred by key stakeholders in specifically fruits and vegetables production value chain in Sri Lanka. Multiple approaches was operated to gather both primary and secondary data by way of Review of Literature, Focus Group Discussions and Key-Informant Interviews where a structured questionnaire-based personal interview-oriented stakeholder survey was carried out with over 140 individuals attached to organic fertilizer oriented agri-food value chains. The responses of whom were captured by setting a set of objective statements and each respondent was directed to score on them using 10-point likert-scale. The values provided on this scale were subjected to Exploratory Factor Analysis techniques to test for their 'validity' and 'reliability' and the outcome was used to derive Mean Attitude Score (MAS). Exploratory Factor Analysis shows that those instruments can be catalogued objectively under four attributes, termed as: 'Self', 'Market', 'Government' and 'Judiciary'. The outcome of Kruskal Wallis test revealed that at least those preferences of one stakeholder type is different from others. The outcome of the whole study provides insights as to how an appropriate policy environment with right instruments can be formulated to promote organic agriculture, where the majority of stakeholders highly preferred 'Government Intervention' to regulate followed by other institutions to facilitate such efforts.

Keywords: Agri-food value chain, Organic fertilizer, Promotional instruments, Stakeholder preferences

Farmer Education and Potato Storage in Sri Lanka: Present Status and Future Prospects

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Potato is a highly demanded root crop in Sri Lanka while the land extent of potato cultivation is about 5,000 ha. The average annual production is around 80,000 metric tons. However, the year-round availability of potato is depending on industrial-scale storage and potato yield. Sri Lanka does not have a sound solution for potato storage problem yet. Therefore, the present study aims to identify the present situation of storage facilities and farmer education level on potato to reduce post-harvest losses and imports with the almost expanding potato market in off season. The study was based on primary data gathered through pre-structured questionnaires from 100 potato farmers selected using the snowball sampling technique. Out of 100 farmers, 48 farmers were selected from Nuwara-Eliya district and others were selected from Badulla district. Data analysis was done using descriptive and interracial statistics with support of Minitab-16 software. Results indicated that, there are strong relationships with farmer education level between availability of the storage facilities (p-value=0.000), farmer willingness to store potato (p-value=0.000) and neediness for convenient storage facilities (p-value=0.005). Educated farmers are most like to store potatoes to use during off season. However, majority (76%) of farmers do not have convenient storage facilities. Therefore, most (46%) of them never store potatoes and sell total harvest at lower price as soon as possible from harvested date. However, 87% of them need convenient storage facilities. Therefore, the present study has clearly brought out the urgency of convenient storage facilities for potato in order to expand potato market. Most importantly, appropriate knowledge delivery method while enhancing the education status is needed to encourage potato storage in Sri Lanka which ensures food security and poverty reduction. This further helps to reduce post-harvest losses and potato imports in Sri Lanka. Also, this study will be continued to identify the effect of other factors on the potato storage.

Keywords: Convenient storage facilities, Education Level, Post-harvest losses, Potato cultivation

Climate Change, Environmental Management and Cleaner Agriculture

The Effect of Public Influence on Policy Alternatives to Mitigate Climate Change Risks: A Comparative Study in Developed and Developing Countries

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Agriculture plays a decisive role in the global economies and remains central to the lives of a great many people around the world. It has been widely accepted that climate change has caused numerous challenges to the agriculture sector, but comprehensive and effective steps are yet to be taken by some nations. Sri Lanka is identified as one of the nations severely affected by climate change risks and falling into this category. This is a policy deficiency because most developed economies have taken policy decisions to limit carbon dioxide emissions that cause climate change even though their economies are dependent on the fossil fuel. During the past decades public opinion has shifted to concern climate change risks across the world demanding government policy alternatives to limit the carbon dioxide emissions. In this context, in developed economies public opinion has substantially influenced development of policy alternatives to investment in renewable energy to reduce carbon dioxide emissions caused by fossil fuels. This benefits the agricultural sector because the agriculture is the sector worst hit by climate change. To address this policy gap, the objective of this paper is to explore how Sri Lankan public concern about climate change and agriculture effects on policy alternatives to mitigate the climate change risks, by comparing it with the same trend in the United States. The secondary data obtained from the Google trends information from 2015 – 2020, and the emissions data disclosed by fossil fuel companies for the same period. Excel spreadsheets are used to give graphic and numerical outputs in a time – series using descriptive analysis method. The outcome of our graphical analysis reveals public concern has had a real impact on emission reductions in the US, an advanced economy, leading to a reduction of over 100 million tonnes of emissions annually, while, Sri Lankan's public concern about climate change is highly unlikely influence policy alternatives to avoid climate change risks, leading to increasing emissions and risking the agricultural industry and the Sri Lankan economy.

Keywords: Agriculture, Carbon dioxide emissions, Climate change, Policy, Public Concern

Seasonal Variation of Rainfall in Vadamaradchi Area in Jaffna District, Sri Lanka

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The accurate knowledge of rainfall amount, intensity and frequency and understanding of seasonal and annual pattern of rainfall will help to planning the crop. The shortage or excess of rainfall amount will lead to the reduction in yield. The statistical technique was used to analyze the rainfall in Vadamaradchi area for the period of 2013 to 2019 with the available rainfall data from three agrarian divisions; Ampan, Puloly and Karaveddy. The annual rainfall has decreasing trend. The four seasons are clear and dominated by South west monsoon (SWM) and North East monsoon (NEM) followed by Second inter-monsoon (SIM) and First Inter-monsoon (FIM) in all three areas. Out of total amount of annual rainfall (204.8 mm), 18.52 mm (9.04%) received in FIM season, 70.15 mm (34.25%) received in SWM season, 56.22 mm (27.45%) received in SIM season and 59.92 mm (29.25%) received in NEM season during 2013 to 2019 in Ampan agrarian division. Similarly, 7.31%, 41.10%, 20.07% and 31.52% for Karaveddy and 5.02%, 42.45%, 27.47% and 25.05% for Puloly, respectively, for FIM, SWM, SIM and NEM. The analysis of variance of average monthly rainfall was not significantly differs among three divisions. From this study, it can be concluded that the areas were under dry weather condition with shifting of seasonal rainfall pattern. The SWM and NEM provide high amount of rainfall followed by SIM and FIM. The shifting of seasons was observed clearly. Therefore, further studies are needed to find out the onset and offset of rainfall to plan the cropping pattern.

Keywords: Monsoon, Rainfall, Vadamaradchi

Seasonal Variations of Plant Pigments in New Hybrid Tea [*Camellia sinensis* (L.) O. Kuntze] Population

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Tea is an ancient and popular beverage. It has various merits for human health such as antibacterial, antiviral, diuretic, and anti-carcinogenic effects. Tea has been consumed in the world such as green, black, yellow, white, oolong and purple teas. Plant pigments available in tea has many health properties. It is important to develop new tea cultivars with variable amounts of pigments. This study focused on quantification of chlorophylls and carotenoids in fresh tea leaves of a new hybrid progeny derived from crossing TRI 3055 and TRI 2043 during December 2019 to January 2020 as dry season and February 2020 to March 2020 as wet season. Two fresh leaves and bud from 68 accessions were obtained from field number 9, St.Coombs state, with 2 replicates from one sample. The annual pigments contents in fresh tea leaves were extracted using acetone 80% (v/v) and quantified using standard spectrophotometric method. Absorbance of chlorophyll a, chlorophyll b and carotenoids were measured at 663 nm, 646 nm and 470 nm, respectively. Significant difference ($p<0.05$) was not observed for chlorophyll a and chlorophyll b, total chlorophyll and carotenoids between accessions developed from direct cross and reciprocal cross. Content of chlorophyll a, chlorophyll b and total chlorophyll was significantly high in wet season. Total chlorophyll content was varied from 3.90 mg/g to 9.24 mg/g. Total carotenoids concentration was ranged from 0.24 mg/g to 0.77 mg/g. Accession number 34 reported high carotenoid (0.58 mg/g) and low chlorophyll content (4.16 mg/g), which could be a potential cultivar for yellow tea production. Accessions numbers 41, 45, 109, 78 and 151 with high chlorophyll content were identified as good accessions for black tea production. Information generated from the study is useful in identifying potential accessions for producing yellow tea and black tea.

Keywords: Black tea, Hybrid population, Tea pigments, Yellow tea

The Effect of Indian Ocean Dipole (IOD) Events on the Second Inter-Monsoonal Rainfall in the Dry Zone of Sri Lanka

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Indian Ocean Dipole (IOD) is an ocean-atmospheric coupled phenomenon associated with the east-west gradient of Sea Surface Temperature (SST) anomalies in the tropical Indian Ocean. The positive (warm) phase of IOD leads to enhanced rainfall in the western Indian Ocean and diminished rainfall in the south eastern Indian Ocean, while the opposite is true for the negative (cold) phase. Any ocean atmospheric variations in the Indian Ocean is strongly associated with the rainfall anomaly of Sri Lanka. Present study examined the influence of IOD on the Second Inter-monsoonal (SIM) rainfall (October and November) as a useful observation for seasonal climate forecasting of *Maha* seasons. Fifteen agro-meteorological stations, scattered in the dry zone, covering six agro-ecological regions, were selected. Daily rainfall time series for 44-years (1976-2019) were collected. The Dipole Mode Index (DMI), *i.e.* SST gradient between the western equatorial Indian Ocean and the south eastern equatorial Indian Ocean, were used to identify the positive (>+0.4 °C) and negative (<−0.4 °C) IOD events. Eight positive years and four negative years were identified during the SIM season for the study period and compared them with remaining neutral years. Means of five rainfall indices, namely, cumulative seasonal rainfall, maximum rainfall received within a day, number of wet days (rainfall > 1 mm), heavy rainfall events (> 90^{th} percentile) and maximum count of consecutive dry days were statistically analysed. The results revealed a significant increase in mean cumulative rainfall, number of wet days and heavy rainfall events during the IOD-positive years ($p<0.05$) and an apparent negative anomaly of those events during the IOD negative years. The mean maximum consecutive dry days showed a distinct negative (positive) anomaly with the positive (negative) IOD events. However, further investigations are suggested to elucidate the anomalous variation of rainfall by the other climatic drivers over IOD impact.

Keywords: Dipole Mode Index, Dry zone, Indian Ocean Dipole, Rainfall anomaly, Second inter-monsoon

Eco-Friendly Technologies Developed to Curb Chemical Fertilizer Use: What Are the Perks Available and Limitations Faced by Dry Zone Paddy Farmers in Sri Lanka?

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Numerous health and soil related problems are being reported in the paddy farming areas of Sri Lanka, and most of which have been pinpointed as a result of excessive use of Chemical Fertilizer (CF). In light of this, this study was focused to identify the perks available and limitations faced by paddy farmers to adopt the Eco-Friendly Technologies (EFTs) developed in the form of Bio Fertilizer and Bio-Char through a multi-stage project funded by the National Research Council of Sri Lanka. Both qualitative and quantitative techniques were employed to collect and analyze the first-hand information and data from 100 registered paddy farmers to the project from Anuradhapura and Kurunegala districts. An in-depth semi-structured questionnaire-based personal interview and a field visit were carried out where each respondent responded those 'attitudinal statements' explaining these phenomena on a 10-point Likert-scale. The outcome of Confirmatory Factor Analysis techniques sorted out those statements into 6 specific criteria, namely: 'Regulatory impact' (REG); 'Cost of application' (CST); 'Effect on environment' (ENV); 'Expected performance' (PER); 'Availability of related services' (SER), and 'Level of Acceptance' (ACP). It was found that farmers judged that those statements explaining ENV as the "most important" to use EFTs introduced against CFs followed by those specified under the PER and CST. Further, the results highlight the fact that those paddy farmers were much concerned about the accessibility to EFTs (i.e. markets) and economic incentives available (i.e. finance / subsidies) to switch effectively from CF, as they do not want to see any significant failures in the markets and policy/legal environment. This highlights the importance of bringing right policy instruments covering different time spans (i.e. short to medium to long-term) and generated and governed by multiples institutions (i.e. private - firms/markets; public - government and at times judiciary) to minimize those potential failures perceived on the mind-set of real users.

Keywords: Agriculture policy, Chemical fertilizers, Eco-friendly technologies, Farmer perceptions, Paddy farming

Farmer Adaptation to Climate Change and Implications for Household Food Security in Anuradhapura District of Sri Lanka

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Climate change manifestations can have detrimental effects on the rural farmer households in developing countries. This study investigates farm-level adaptation to climate change and its implications for household food security in Anuradhapura district of Sri Lanka. Stratified sampling technique was followed to select a sample of 110 paddy farmers in Anuradhapura district and they were surveyed using a structured questionnaire. An ordered logistic regression was carried out to identify the impact of climate change adaptation practices at farm-level on the household food security. A Confirmatory Factor Analysis (CFA) was employed to quantify and validate the statements reflecting the determinants such as social capital (i.e. social networks), climate change adaptation and exposure to climate change. Indices were computed to quantify these variables using the responses provided by the farmers, which were then used as independent variables. Farmer households were categorized into four food security levels ranging from food secure to severely food insecure using the Household Food Insecurity Access (HFIA) survey technique. The study revealed that over 75% of the households were mildly food insecure and more than 80% of the farmers adopted climate change adaptation practices. According to the logistic regression analysis, farmers who practiced climate change adaptation strategies are more food secure than those who did not. The study also revealed that, social network impact, exposure to climate changes, climate change adaptation and level of education have significant ($p<0.05$) impacts on the level of household food security. Farmers identified the lack of financial assistance followed by inadequate knowledge and extension services to be the two major reasons for non-adoption. Therefore, policies should focus on encouraging farmer communities to follow climate change adaptation strategies through awareness, training and by increasing household endowments. Empowerment of farmers is critical in facilitating climate adaptation strategies to reduce household food insecurity.

Keywords: Adaptation, Climate change, Farmer household, Food security

Crop Production Technologies and Natural Resource Management

Sample Survey to Identify Land-Use Pattern of Rice-Based Cropping Systems in Sri Lanka

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A survey was conducted to identify land-use pattern of rice-based cropping systems in the country using 9000 samples at the end of the *Yala* season 2019. Data were gathered by visiting selected paddy fields in a *yaya* (track) of those sample locations. Data were statistically analysed using the chi-square test in SAS. Out of the lands surveyed, 3.5% of the lands were abandoned. The percentage of abandoned paddy lands were significantly high ($p<0.0001$) in rain-fed areas (7.4%) compared to major (1.4%) and minor (2.5%) irrigation areas. Western province had the highest number of abandoned paddy fields (27%) while it was the lowest in Uva province (0.0%). Out of the total plots surveyed, 67% occupied by paddy and 29% was kept as fallow. Moreover, 1.6%, 1.5%, 0.4% and 0.3% were occupied by other field crops (OFC), vegetables, banana and perennials, respectively. The least % of lands cultivated by paddy (53%) and the highest % of lands kept fallow (43%) was observed in the Northern province. Uva province was dominated by the OFC cultivation (15%) while vegetable was dominated in the Central province (9.4%). Banana was mainly cultivated in the Sabaragamuwa province (5.4%) while 0.9% of paddy lands in Western province were converted to perennial crops. Reasons for diversifying paddy lands to alternative land-uses need to be explored, and the current findings will be useful in making future decisions on rice-based cropping systems to ensure sustainability of those lands.

Keywords: Irrigation, Land use-patterns, Rice-based cropping systems

Estimation of Vegetation Structure and Investigation of Environmental Issues on Pigeon Island National Park, Trincomalee, Sri Lanka

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This study was carried out to assess the floristic diversity in Pigeon Island National Park (PINP), and to recognize the activities of stakeholders for the upcoming threats and issues on PINP. The assessment was conducted from April to September 2019 and twenty-one plots (16 × 16 m^2) were randomly laid in PINP to assess the floristic diversity. Moreover, data were collected through questionnaire survey (80 individuals) and investigated PCZRSM project activities followed by outcome evaluation to analyze threats, issues and the mitigation actions shadowed by the stakeholders of PINP. Diversity and evenness of each plot was calculated using Shannon-Wiener diversity index and Pielou's evenness index respectively. General Linear Model (ANOVA) and correlation were employed to analyze the data using MINITAB 16 software. Results indicated that the study site is composed of 72 different floral species and Shannon-Wiener diversity index and evenness ranged from 0.593 - 3.429 and 0.568 - 0.972, respectively. There were significant differences in diversity and evenness among plots ($p<0.05$). The outcomes demonstrated that the plant species diversity of entire PINP region contemplated was 3.693 and the evenness was 0.751. Such values imply that the PINP comprises rich floristic diversity, and it plays a unique role in coastal vegetation due to its biological and ecological significance. The results of questionnaire survey indicated that 65% of individuals said the actions of stakeholders and PCZRSM Project support for the development of PINP. Further, analyzed outcome evaluation revealed that management measures made for the long-term sustainability of the park by the stakeholders are needed. Moreover, developed Pigeon Island Management Plan with community co-management schedule is needed for this national park. Achievement of the co-management framework through Pigeon Island Management Committee is also vital to coordinate with all other stakeholders for the effective administration measures.

Keywords: Co-management plan, Floral diversity, Pigeon Island, Shannon-Wiener diversity index

Enhancement of Lipid Content in *Chlorella* sp. by Providing Stress Conditions during Cultivation

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Lipids from microalgae are renewable source of biofuels. Large amounts of algal biomass are produced under optimal growth conditions with relatively low lipid content. However, they have potential to accumulate high amount of lipids under stress conditions. This study was aimed to enhance the lipid content of *Chlorella* sp. by providing stresses such as deficiency of nitrogen and zinc and excessive salinity during cultivation. Bold's Basal Media (BBM) was used as the culture media. Two control sets were used; one set cultured by adding appropriate amount of BBM and other set cultured by adding 3 times of BBM. Five sets each of three treatments and two controls were maintained in batch reactors arranged randomly. Light intensity was kept constant. Photo period cycle was followed to optimize microalgae growth. Air spargers were applied for uniform mixing. From the beginning, all samples were grown under the same conditions with adding appropriate amount of BBM except two batches; Zn stressed batch which was maintained without adding Zn from the beginning and the second control which was added with 3 times of BBM. After 7 days, stresses were introduced to the remaining batches except controls and Zn stressed batch. N stressed set was maintained without adding N. Salinity stress set was treated with extra amount of NaCl (2 M). One set from each treatment/ control was harvested on 4^{th}, 8^{th}, 11^{th}, 14^{th} and 17^{th} day of cultivation. Maximum optical density was achieved after 14 days. Harvested biomass was dried and lipids were extracted from dried biomass using chloroform: methanol (1:1) mixture. Lipid content of stressed samples increased, compared to control samples (highest was 16.9%). Zn stressed samples achieved highest lipid percentage (highest was 23.3%). After certain period of time (14^{th} day), lipid content of stressed samples decreased. Gas chromatographic analysis of the lipid identified the major fatty acids such as C11:0 (4.6%), C18:0 (35%), C18:2 (30%) and C21:0 (6%). Therefore lipid content can be increased significantly by providing stresses during cultivation and zinc deficiency was found to be more effective than other stress conditions studied to enhance the lipid content of *Chlorella* sp.

Keywords: Algal lipids, Biofuel, Microalgae, Stress conditions

Effect of Culture Media States (Liquid and Solid) on Non-Parametrical Measurements of *In-Vitro* Sub Culturing of *Anthurium* 'Lady Jane'

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Anthurium 'Lady Jane' which was introduced in Hawaii, is a hybrid plant belonging to family Araceae with higher market demand as an indoor potted plant and cut flower due to attractive glossy shape dark green foliage and colorful flowers. Micro-propagation is used to production of plants to fulfill the market demand. However, a high cost associated with agar as a solidifying agent is major drawback in micro-propagation. Therefore, this study was conducted to identify low cost preferable media and physical matrices for agar in 'Lady Jane' production. Effect of Murashige and Skoog (MS) basal medium with 6-Benzylaminopurine (BAP) (1 mg/1L) solidified with agar (control experiment) and liquid medium supported with pure cotton wool on morphological and quality parameters of 'Lady Jane' plants were investigated. Six-month old 'Lady Jane' plantlets grown *in-vitro* were used as explants. Leaf color, stiffness of the leaves and strength of the stem were considered. Data were recorded at three-week intervals up to two months. Data were analyzed through one-sample Wilcoxson sign rank test by IBM SPSS software. Result showed better performance for both liquid and solid medium. Plantlets in Liquid and Solid medium both are appear healthier and greener. Cost analysis showed that 140 Rs/ liter of medium could be reduced by using pure cotton wool in a liquid medium instead of solid medium with agar. Parametrical measurements showed better performance for liquid media. Final results indicated the liquid media is better for production of higher number of healthy 'Lady Jane' plantlets.

Keywords: *Anthurium* 'Lady Jane', Low cost, Media states, Non-parametrical, Pure cotton

Impact of Different Border Crops on Growth and Yield Performance of Cauliflower (*Brassica oleracea* var botrytis L.) Varieties

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Cauliflower produces best curd in cool and moist climate and affected mainly by some pests. Natural pest control provides a safe and more sustainable approach for managing pest populations. The use of border crop was an eco-friendly method for the management of pests. A research was conducted to assess the impact of different border crops on growth and yield performance of cauliflower varieties at Faculty of Agriculture, Kilinochchi during December 2018 to April 2019. Experiment was carried out in a split plot design with three replicates. Four different borders such as sunflower (T_1), lemongrass (T_2), chrysanthemum (T_3) and no border (T_4) were selected as main plot treatments and two different cauliflower varieties such as Mareet (V_1) and White Shot (V_2) were used as sub-plot treatments. The cauliflower varieties were planted at the spacing of 60 cm × 45 cm. All the agronomic practices were done according to the recommendations of the Department of Agriculture except plant protection methods. The growth, plant protection measures and yield parameters were recorded. ANOVA and Duncan's Multiple Range Test (DMRT) were performed to find out the significant differences among the treatments. Type of the border and the variety were not significant for plant height and number of leaves per plant. The curd weight, curd circumference, curd diameter, total yield and marketable yield was significantly different among the border crops and the highest was observed in the lemongrass border (T_2).There was no interaction effect between type of border crops and varieties. The varieties of cauliflower showed the non-significant effect on the yield parameters and the highest was recorded in White Shot variety. Marketable yield and infested yield were significantly differed among the different border crop treatments and the highest marketable yield was obtained from lemongrass border (T_2) in both varieties. The plant protection parameters such as number of damaged leaves per plant and number of damaged curds were significantly differed among the border crops and the highest was recorded in control (T_4) treatment in Mareet variety. It can be concluded that lemongrass border and White Shot variety can be recommended as the best treatment combination for cauliflower cultivation in Kilinochchi district of Sri Lanka during *Maha* season.

Keywords: Border crops, Cauliflower, Curd, Growth and yield, Plant protection parameters

Demand for Eco-tourism: An Estimation of the Recreational Value of the Rumassala Sanctuary

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Eco-tourism is one of the most trending revenue-generating industries contributing to Sri Lanka's economic development in many ways. Rumassala sanctuary, situated in the south of Sri Lanka is an ideal destination for eco-tourism. Due to its unique locality surrounded by hills, forests, and the beach, Rumassala is rich in biodiversity making it more attractive for tourists. This attraction itself can lead to rapid resource degradation if the proper valuation of the resource is not conducted. Therefore, this study aimed to estimate the recreation value of the area and the benefits of managing the Rumassala sanctuary as a national park for eco-tourism. Data were collected from domestic tourists (n=125) visiting the site through an onsite survey administering a structured questionnaire. A simple random sampling technique was used. An environmental valuation approach: Individual Travel Cost method was employed to estimate the recreation value, entrance fee as well as factors affecting the visitation rate. Results show that the cost, distance, and the quality of the park affected the visitation rates positively and significantly. The results revealed an estimated consumer surplus of Rs. 9,672 per person and the recreational value to be Rs. 15,797 per person. The visitors were willing to pay a mean value of Rs.35 as the entrance fee. Imposing an optimum entrance fee through proper valuation can be expected to generate enough funds for the management and conservation of the area. Given that the park quality is also a decisive factor, adequate allocation of money for improved facilities can attract more tourists both local and foreign to Rumassala.

Keywords: Eco-tourism, Recreational value, Rumassala, Travel cost method

Food and Nutrition

Comparative Study of Glycaemic Impact Analysis in Spices Incorporated Yoghurts

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The prevalence of diabetes mellitus, characterized by high blood glucose levels, is increasing worldwide. Blood glucose level of individuals can be controlled by incorporation of tropical herbs and spices in the diet. The main objective of this study was to manufacture spice oleoresin (*Cinnamomum zeylanicum, Curcuma longa*) incorporated high quality novel dairy yoghurts with reduced glycaemic impact. Developed yoghurts were compared with typical dairy yoghurt as the control, mainly for the glycaemic impact after consumption using 16 healthy volunteers in a randomized crossover study. Blood glucose concentration of individuals was measured using a blood glucose monitoring system at fasting state and at 30, 45, 60, 90, 120 min following ingestion. Glucose response curves were plotted for individuals and control was used as the standard. In addition, shelf life, compositional and physiochemical properties were determined for prepared yoghurts. Shelf life for novel yoghurts was estimated as 15 days at 4±1°C. Developed novel and control yoghurts were within the acceptable standards and significant ($p>0.05$) differences were not observed in compositional and physiochemical properties between them. However, significant ($p<0.05$) reduction was observed in peak blood glucose concentration and area under the curve (AUC) of individuals for both novel yoghurts compared to the control. Percentage peak glucose concentration reduction for cinnamon and turmeric yoghurts were 9.61% and 9.26%, respectively, compared to the control. Mean peak blood glucose concentration for control, cinnamon and turmeric yoghurts were 113.38±6.39, 102.50±6.00, 102.88±5.38 mg/dL, respectively, and mean AUC were 11951±523, 11012±611, 10941±530 [(mg/dL) x min], respectively. Hence, novel yoghurts with reduced glycaemic impact, were observed to be effective in minimizing the risk of diabetes.

Keywords: Area under the curve, Blood glucose concentration, Cinnamon, Glycaemic impact, Turmeric

Evaluation of Nutritional Composition and Antioxidant Properties of *Cissus quadrangularis* ('Pirandai')

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Cissus quadrangularis ('Pirandai') is one of the edible plants available in the Northern region of Sri Lanka. However, it remains underutilized due to the lack of awareness of its health beneficial properties. This study was aimed to evaluate the nutritional composition and antioxidant properties of *C. quadrangularis* stem. Fresh *C. quadrangularis* stems were collected from the home gardens located in Navatkiri, Jaffna and oven-dried at 45 °C for 48 hours until a stable moisture content was reached. Dried samples were analyzed for nutritional composition such as crude protein, crude fat, crude fiber, ash, moisture, and carbohydrate contents. The extract was obtained from both fresh and dried stems by using 70% (v/v) methanol and 70% (v/v) ethanol as solvents. Extraction of the fresh and dry stems was done by shaking the mixture of sample and solvent at 200 rpm using a mechanical shaker at ambient conditions for selected time durations (2, 4, and 6 hours). These dried extracts were used to analyze antioxidant properties, namely, Total Phenolic Content (TPC), Total Antioxidant Capacity (TAC), and 2,2-Diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity. Composition analysis of dried stem powder yielded 6.02±.023% moisture content, 3.40±0.26% crude fat, 21.58±0.88% crude protein, 53.61±4.43% carbohydrate, 17.11±0.77% ash, and 4.30±0.28% crude fiber. Among all the samples tested, the significantly highest ($p<0.05$) TPC and TAC (29.3±0.3 mg gallic acid equivalent/g dry matter, 16.38±0.44 mg ascorbic acid equivalent/g dry matter, respectively) were obtained in the fresh sample with 6 hours of methanolic extraction. The fresh sample showed the lowest IC_{50} value (0.029±0.002 mg/mL), which means the highest antioxidant activity among the tested samples. Fresh samples were significantly higher ($p<0.05$) in the antioxidant properties than the dried samples. The methanolic extract of all fresh and dried samples significantly higher in the antioxidant properties (TPC and TAC and antioxidant activity) than the ethanolic extract of corresponding samples. Gas chromatography analysis identified the different types of fatty acids present in dry powder of *C. quadrangularis* stem (C8:0, C10:0, C12:0, C14:0, C16:0, C17:1, C18:1, C18:2, and C20:1). Since *C. quadrangularis* stem has good nutritional and antioxidant properties, it could be used as a natural health promoter.

Keywords: Antioxidant properties *Cissus quadrangularis,* Gas chromatography analysis, Proximate composition

Comparative Phytochemical Analysis of Fruit Pulps of Palmyrah Palms of Different Geological Locations of Sri Lanka

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Palmyrah palm has diverse biochemical properties due to the presence of nutritional and bioactive compounds in different parts of the tree. The objective of the study was to identify, determine and to perform a comparative analysis of existing phytochemicals in the fruit pulp of palmyrah palm grown in different geological locations of Sri Lanka such as Point Pedro, Puttalam, Valikamam and Delft. The aqueous extracts of palmyrah fruit pulp obtained from four different locations of Sri Lanka were screened for different phytochemicals such as flavonoids, glycosides, tannins, phenols, terpenoids, gum and mucilages, saponins, alkaloids, carbohydrates and proteins. All the four fruit pulps of palmyrah palm obtained from different locations showed positive results for flavonoids, glycosides, tannins, terpenoids, gum and mucilages, saponins, carbohydrates and proteins. There were significant differences in the quantities of flavonoids, tannins, proteins, carbohydrates and total sugars among the palmyrah fruit pulps of the four locations of Sri Lanka. The pulp of palmyrah fruit collected from Point Pedro showed significantly higher quantity of flavonoid (0.09 mg/mL), tannin (0.18 mg/mL) and protein (0.22 mg/mL) than that of other three locations. The mean carbohydrate content (2.75 mg/mL) of the palmyrah fruit pulp of Delft was significantly higher than that of other three locations. The mean total sugar content (0.11 mg/mL) was significantly higher in the pulp of palmyrah from Valikamam than that of other three locations. This study revealed that the palmyrah pulp obtained from the palms of different locations had specifically different phytochemicals significantly higher in their quantities. However, palmyrah fruit pulp of Point Pedro location was rich in important phytochemicals such as flavonoid, tannins and proteins than that of other three locations of Sri Lanka. Therefore, it could be used for further studies in traditional medicine and other palmyrah fruit pulp related investigations.

Keywords: Flavonoids, Fruit pulp, Geological locations, Palmyrah, Phytochemicals

Evaluation of the Bran Extracts of Rice (*Oryza sativa* L.) and Selected Bean (*Phaseolus vulgaris* L.) Varieties for Their Anti-Oxidative and Anti-Hyperglycemic Potentials

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Diabetes mellitus is a serious metabolic disorder characterized by hyperglycemia. One holistic approach to control the hyperglycemia condition is to partially inhibit the carbohydrate hydrolyzing enzymes during digestion of food. In this study, anti-hyperglycemic and anti-oxidative potentials of the bran extracts of rice (*Oryza sativa* L.) and some selected beans (red bean, red kidney bean and white bean) (*Phaseolus vulgaris* L.) obtained with 80% ethanol-water mixture were compared. The total phenolic content, the α-amylase and α-glucosidase inhibitory potentials, ferric reducing antioxidant power (FRAP), 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid (ABTS) radical scavenging activity and 2,2-diphenyl-1-picryl-hydrazyl-hydrate (DPPH) radical scavenging activity of the extracts were studied *in-vitro* using the relevant assays. Results showed that red bean bran extract contained the highest phenolic content (0.122 mg of Gallic Acid Equivalent/g of extract). The mean of the FRAP values of the extracts were ranged from 48.98 to 75.94 μmol $FeSO_4$/g of bran extract. Bran extract of red kidney bean displayed the highest ferric reducing power (75.94 μmol $FeSO_4$/g) compared to any other bran extracts. Bran extract of rice displayed the highest inhibitory effect against the α-amylase activity (96.18%) while bran extract of red bean showed the highest inhibitory effect against the α-glucosidase activity (39.57%). This study concluded that the bran extracts of rice and the selected beans were potent sources of natural antioxidants and good postprandial hyperglycemia regulators.

Keywords: Antihyperglycemic activity, Antioxidant activity, Bran extracts, Diabetes

Evaluation of Nutritional Composition and Antioxidant Properties of Selected Seaweeds Available in the Northern Region of Sri Lanka

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The demand for seaweed is increased recently due to its high nutritional and medicinal values. Therefore, this study evaluated the nutritional composition and antioxidant properties of methanolic extracts of selected green (*Enteromorpha* spp.), brown (*Turbinaria* spp.), and red (*Laurencia* spp.) seaweeds collected from the coastal area of Delft Island in the Northern region of Sri Lanka. Collected samples were dried under shade until they reached a constant moisture content. These dried samples were powdered and analyzed for proximate composition (crude protein, crude fat, crude fiber, ash, moisture, and carbohydrate contents) by AOAC methods. Among the three selected species, *Laurencia* spp. contained the highest ($p<0.05$) amount of crude protein (42±2.31%), and ash content (38.99±1.02%), whereas *Enteromorpha* spp. had the highest ($p<0.05$) carbohydrate content (47.92±2.07%) and *Turbinaria* spp. contained the highest ($p<0.0.5$) amount of fat content (2.34±0.02%). The crude fiber content of the selected seaweeds ranged from 8.96±0.15 to 9.73±1.10%. The selected dried samples were extracted by 70 % (v/v) methanol for different durations (2, 4, and 6 hours) at 200 rpm using a mechanical shaker for the antioxidant analysis. Extracts were analyzed for antioxidant properties such as total phenolic content (TPC) [expressed as Gallic Acid Equivalent/ g dry matter (GAE/g DM)], total antioxidant capacity (TAC) [expressed as Ascorbic Acid Equivalent/ g DM (AAE/g DM)], and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity (expressed as IC_{50} value which is inversely related to antioxidant activity). The highest TPC and antioxidant activity were obtained in the extract obtained after 6 hours of extraction compared to 2 and 4 hours. Among the species analyzed, *Turbinaria* spp. exhibited the highest ($p<0.05$) content of TPC (8.10 ± 0.72 mg GAE/g DM and antioxidant activity (IC_{50} value- 0.08 ± 0.05 mg/mL). Gas chromatography analysis identified the different types of fatty acids present in three seaweed species (C8:0, C10:0, C11:0, C11:1, C12:0, C16:0, C16:1, C17:1 and C18:1). This study concluded that the tested seaweeds showed the beneficial health properties and could be effectively used to prepare value-added food products.

Keywords: Antioxidant properties, Nutritional composition, Seaweeds

Resistant Starch Contents of Selected Rice (*Oryza sativa* L.) Varieties of Sri Lanka

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Rice is the staple food of Sri Lankan population. Resistant Starch (RS) provides health benefits such as improvement in carbohydrate and lipid metabolism and reducing the risk of diabetes and cardiovascular diseases. This study was aimed to analyze RS contents of different varieties of rice available in the Northern Province of Sri Lanka. An enzyme method using amyloglucosidase and pancreatic α-amylase enzymes was used to estimate the RS and non-RS content. The starch was hydrolysed by acid and the reducing sugar was estimated by DNS method to determine the total starch content. Among the rice varieties selected, eight were improved varieties namely, *Bg 250, Bw 351, At 362, Bg 366, Bg 406, Ld 365, Ld 356* and *Bg 361* and seven were traditional varieties namely *Murungagayan, Suwandal, Periyavellai, Pachchaperumaal, Thattuwee, Kallundaai* and *Moddakaruppan*. RS contents of the rice varieties ranged from 17.69 ±0.18 to 27.87±0.32%. Traditional rice varieties had RS contents in the range from 20.48±0.18 to 27.87±0.32%. Improved rice varieties had RS contents in the range from 17.69±0.18 to 22.52±0.30%. Mean RS content of traditional rice varieties (23.97±2.1%) was higher than that of improved rice varieties (19.71±0.67%). There were significant differences ($p<0.05$) in the RS contents of all varieties. The *Pachchaperumaal* variety contained the highest (27.87±0.32%) and *At 362* variety contained the lowest (17.69±0.18%) amount of RS. It can be concluded that the RS content varied among the tested rice varieties and the traditional rice varieties had higher RS content than improved rice varieties. Thus, the traditional rice varieties can be included in developing value added novel functional foods and can be useful for the dietary management of patients with diabetes and coronary heart diseases.

Keywords: Improved rice varieties, Resistant starch, Total starch, Traditional rice varieties

Food Processing and Product Development

Development of a Jam from Nam-Nam (*Cynometra cauliflora*) Fruit

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Nam-nam (*Cynometra cauliflora*, Fabaceae) fruit is a good source of nutrients including vitamins A and C. However, a limited number of value-added commercial products of nam-nam is available in the market. Therefore, the aim of this study was to develop a jam from nam-nam fruit with good nutritional and sensory properties and shelf life. Three types of jam were prepared using nam-nam and guava (*Psidium guajava*) and apple (*Malus domestica)* as natural pectin sources (75% of nam-nam fruit and 25% of total guava and apple, 50% of nam-nam fruit and 50% of total guava and apple, 25% nam-nam and 75% of total guava and apple). The samples were subjected to analysis of sensory and proximate qualities and microbial qualities. Sensory analysis was carried out using five-point hedonic scale using 30 untrained panelists. Results were analyzed using Minitab 17.0. The results revealed the significant differences ($p<0.05$) in color, overall aroma, overall texture, overall appearance and overall flavor and the sample that showed the best result (75% nam-nam and 25% guava and apple) was selected for proximate and microbial analysis. The total ash, fat, crude fiber, crude protein, moisture, and carbohydrate contents of the selected formulation were 0.4%, 0.2%, 2.2%, 0.2%, 37.5%, and 59.8%, respectively. The quality characteristics such as pH (3.5) and titratable acidity (0.16%) were also tested. All microbial parameters (total plate count, yeast and mould count, coliforms and *E. coli* count) were below the SLS standards. The jam after storing for 6 weeks had a less mould growth than the recommend standard maximum growth. Therefore, it can be concluded that jam with good nutritional, sensory and microbial qualities can be produced using nam-nam fruit.

Keywords: Microbial analysis, Nam-nam, Proximate analysis, Sensory evaluation

Preparation of Tomato Sauce from Tomato Powder Produced from Conventional and Microwave Vacuum Drying Methods

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This study was aimed to prepare tomato sauce using tomato powder produced by two drying methods; microwave vacuum and conventional drying. Ripen tomatoes of *Thilina* variety were washed, blanched for 1 minute by dipping in hot water at 60 °C and cut into 1 cm thick slices. The slices were dehydrated in conventional dryer and microwave vacuum dryer, ground and packed in sterilized, sealed glass bottles and stored in a cool dry place at room temperature. Tomato sauces were prepared from produced powders according to the Sri Lanka Standards (SLS) and their qualities were compared with three branded tomato sauces. Tomato powders and sauces were evaluated for physiochemical properties (color, pH, brix, titratable acidity, ascorbic acid content and viscosity), proximate composition, antioxidant properties [total phenolic content (TPC), total lycopene content and antioxidant activity] and microbiological qualities (total plate count, yeast and mould count and *E. coli* count). Changes in the quality of the powders and sauces were evaluated up to 5 months of storage at room temperature. Sensory evaluation was carried out using 5 points hedonic scale using 30 untrained panelists. Results of this study showed that physiochemical properties and proximate composition were satisfactory for both tomato powders and sauces during the study period. Lycopene content of sauces prepared from vacuum dried tomato powders (VTP) and conventional dried tomato powder (CTP) were 147.74±0.99 mg/kg and 125.97±0.57 mg/kg, respectively, which were lower compared to that of branded sauces (brand 1 - 198.52±0.83 mg/kg). The highest TPC (32.8± 0.82 mg Gallic Acid Equivalent (GAE)/g) was obtained in the CTP among the powders, whereas, the highest TPC was obtained in brand 1 (77.66±0.82 mg GAE/g) among the sauce samples. Ascorbic acid content was higher (135.12±0.08 mg/100 g) in VTP compared to all the powder and sauce samples studied. Antioxidant activity was high in CTP (10.01±0.87 mg/mL) among all the tested samples. Better sensory acceptance was obtained in the sauces prepared from VTP than sauce prepared from CTP. All samples exhibited good microbial quality for 6 months of the study period, according to the SLS. Overall results revealed that microwave vacuum drying method is successful to preserve color and produce tomato powder with good physiochemical, antioxidant, and proximate properties.

Keywords: Conventional dryer, Dehydrated tomato powder, Microwave vacuum dryer, Tomato sauce

Effect of Microwave Assisted Vacuum Drying and Cabinet Drying Techniques on the Quality Attributes of Pineapple

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Dehydrated organic fruits have gained high demand in the export market. The objective of this study was to evaluate the effect of cabinet drying (CD) and microwave assisted vacuum drying (MW-VD) techniques on the quality attributes of osmotically pretreated pineapple. Fruit slices (50±5 mm×30±5 mm×5±1 mm) were blanched for three minutes before dipping into the 50 °Brix sugar solution for four hours. Osmotically pretreated fruit slices were placed into the driers at different time temperature combinations. Several trials were carried out to both CD (50 °C/ 22 h, 65 °C/20 h, 60 °C /24 h) and MW-VDA (40 °C /40 min, 45 °C /20 min, 40 °C / 50 min, 40 °C/1h). Physical appearance, moisture content and water activity measurements were used to select the optimum conditions of driers for drying process. Half set of osmotically pretreated fruit slices were dried at 60 °C for 24 h using CD and remaining set of fruit slices dehydrated at 40 °C for one hour using MW-VD. Physicochemical analysis such as moisture content, titratable acidity, water activity, total soluble solid, vitamin C, pH, porosity, rehydration ratio, color and microbiological (Total Plate Count) analysis were carried out for dehydrated pineapple slices. Pineapple slices dehydrated by MW-VD were significantly low ($p<0.05$) in moisture content (2.34±0.10% - dry basis) and total plate count (4.55±4.55 CFU/g), while high in acidity (3.54±0.35 mol/L), vitamin C (0.04±0.0024%), porosity (51.30±2.25%), rehydration ratio (1.37±0.07) and total color difference ΔE (26.63±4.53) than pineapple slices dehydrated by CD. Other parameters of pineapple fruit slices dehydrated by two techniques did not vary significantly ($p>0.05$). Results of this study proved that MW-VD technology can be used to produce better quality dried fruit products of pineapple than that of CD technology. Further studies are necessary to address the suitability of commercial level/large scale production.

Keywords: Cabinet drying, Microwave assisted vacuum drying, Osmotic dehydration, Pineapple

Sensory Evaluation of Biscuits Prepared from Wheat Flour and Locally Available Cassava Flour

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The products derived from cassava (*Manihot esculenta*) are high energy foods. Cassava is a cheaper and locally available starchy food in Sri Lanka which is used only for traditional food preparations. Biscuits are ready-to-eat and convenient food products. This study was carried out to develop biscuit using suitable formulation of cassava flour and wheat flour and to study the sensory attributes and overall acceptability of the formulated biscuits. Cassava flour was prepared using several unit operations. Five samples of biscuits containing 10, 20, 30, and 40% cassava flour with wheat flour and a control sample containing no cassava flour were processed. Samples were analysed using 5-point hedonic scale by 25 trained panelists and results were evaluated by analysis of variance and Duncan's New Multiple Range Test (DMRT) using SPSS. Biscuit added with 30% cassava flour was significantly higher in colour, taste, crispiness and overall acceptability when compared to other formulations. No significant differences were reported between 30% cassava flour added biscuit and control biscuit in appearance, colour, taste, and overall acceptability. Crispiness of 30% cassava flour added biscuit was significantly higher than control biscuit. There were no significant differences in appearance of biscuit samples containing 10 to 30% cassava flour. Biscuit added with 40% cassava flour showed the lowest overall acceptability. It is recommended that good quality cassava flour added biscuits may be processed in industrial scale substituting the wheat flour by cassava flour at 30% level.

Keywords: Biscuit, Cassava flour, Overall acceptability, Wheat flour

Controlling Discoloration and Quality Evaluation of Dehydrated *Annona muricata* (Soursop) Powder

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This study was conducted to control the discoloration and evaluate the quality of dehydrated soursop powder. Soursop is a highly nutritious, underutilized and, seasonal fruit crop grown in Sri Lanka. The dehydrated powder form of soursop is one of the ideal preservation modes since its shelf stability and versatility in the usage of many values added product. The discoloration of soursop (enzymatic browning) during the processing can be identified as the major drawback, which affects the final product quality. Ten different treatments [0.5% ascorbic acid, 0.5% citric acid, 0.25% ascorbic acid with 0.25% citric acid, 0.1% sodium metabisulfite (SMS), and control] along with blanching and without blanching were used to control the discoloration. The soursop samples subjected to different pretreatments was dehydrated using convectional air-drying technique (55 °C for 16 hours) and finely ground to obtain the powder form. After the drying, only four treatments, out of ten, were selected owing to the minimum discoloration based on their browning indexes (BI). The best treatment and rehydration ability of soursop powder were selected via sensory evaluation conducted using a semi-trained panel. Moreover, the colour, pH, and titratable acidity (TA) of all treatments were tested throughout 12 weeks storage period under the ambient condition. Subsequently, microbial count and proximate composition were determined for the best treatment. Experiments were conducted as completely randomized design with triplicates and data were analyzed using ANOVA. According to the results, "0.1% SMS without blanching" treatment gave the significantly highest (p<0.05) overall sensory acceptability in both dehydrated powder and its rehydrated juice. BI, pH and TA of the best treatment was recorded as 12.79 ± 0.27, 5.40 ± 0.01, and 1.97 ± 0.05% respectively. Moisture, crude protein, crude fat, crude fiber, ash and carbohydrate of the evaluated soursop dehydrated powder sample were 11.90 ± 0.13%, 13.98 ± 0.17%, 6.08 ± 0.15%, 13.03 ± 0.12%, 5.91 ± 0.24% and 49.10 ± 0.32%, respectively. Total plate count and yeast and mold count were varied from $2.5x10^2$ CFU/mL to $7.3x10^3$ CFU/mL and $3.5x10^1$ CFU/mL to $9.8x10^2$ CFU/mL during the storage period, respectively. Therefore, it can be concluded that "0.1% SMS without blanching" was the best pretreatment to control the enzymatic browning of soursop dehydrated powder with a shelf life of twelve weeks at ambient conditions.

Keywords: Blanching, Dehydration, Enzymatic browning, Soursop

Development of Palmyrah (*Borassus flabellifer* L.) Fruit Pulp Powder Using Spray Drying Technique

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Palmyrah palm *(Borassus flabellifer*) is a multi-beneficial tree. During the fruiting season there is a huge loss of Palmyrah fruits due to inadequacy of techniques to convert the fruits into value added food products. This study was aimed to provide a solution to overcome this problem by developing a method to convert Palmyrah fruit pulp (PFP) into Palmyrah Fruit Pulp Powder (PFPP) using spray drying technique. This study was conducted in a laboratory with spray dryer machine (SP-1500, Japan) using preserved Palmyrah fruit pulp and carrier agents such as maltodextrin and gelatin. After the preliminary trials, two inlet temperatures 160 ℃ and 170 ℃ were selected. Different combination of samples were prepared by using Total solid (TS) Palmyrah fruit pulp, maltodextrin and gelatin. For the 160 ℃ inlet temperature, 2 treatments were designed using 55% TS pulp: 45% maltodextrin and 55% TS pulp: 40% maltodextrin: 5% gelatin ratios. For the 170 ℃ temperature 4 treatments were designed by using 55:45:0, 55:40:5, 60:35:5 and 60:0:40 TS pulp: maltodextrin: gelatin ratios respectively. The developed PFPP was packed in low density polythene bags using a vacuum packing machine and stored in a desiccator at room temperature for further analysis. Ash, moisture, fat, salt, reducing sugar, total sugar, vitamin C, phosphorous, calcium and energy content of the each samples were determined. The sample combination that produced highest yield at both temperatures contained 55% pulp and 45% maltodextrin. Yield produced at 160 ℃ inlet temperature had higher level of physiochemical and nutritional properties but low in productivity than samples produced at 170 ℃ inlet temperature. The developed value added product can be beneficial to both Palmyrah food based producers of the country and consumers around the world.

Keywords: Gelatin, Maltodextrin, Palmyrah fruit pulp powder, Productivity, Spray drying technique

Effect of Different Processing Methods on Resistant Starch Contents of Selected Rice Varieties

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Resistant starch (RS) is considered to possess several health benefits. The content of RS in different varieties of rice in the Northern Province of Sri Lanka and the effect of different traditional methods of processing on RS content were determined. Five commonly consumed rice varieties [two improved (*Bg 250* and *Bw 351*) and three traditional varieties (*Periyavellai, Pachchaperumaal* and *Moddakaruppan*)] were selected. Samples were processed by roasting, cooking with and without draining of excess water and cooking the presoaked rice without draining the excess water. The total starch, non-RS and RS contents before and after processing were estimated. The highest and lowest amounts of RS were found in raw *Pachchaperumaal* (27.87±0.32%) and *Bw 351* (18.94±0.26%) varieties, respectively. When roasted, highest and lowest amounts of RS were found in *Bw 351* (11.09±1.29%) and *Bg 250* (7.32±1.68%), respectively. Further, *Bw 351* contained highest amount of RS when cooked without draining the excess water (11.63±1.2%) and with draining excess water (11.40±0.50%). *Periyavellai* contained lowest amount of RS when cooked without draining the excess water (7.04±0.5%) and with draining excess water (4.45 ±0.60%). *Periyavellai* contained the highest amount of RS (14.50±0.84%) and *Moddakaruppan* contained the lowest amount of RS (11.75±0.58%) when the rice was pre-soaked before cooking and without draining the excess water. On the basis of complete randomized design, cooking methods have effect on RS content ($p<0.05$). The RS contents of raw rice and pre-soaked rice cooked without draining of excess water were significantly different. Different processing methods have significantly reduced the total starch, non-RS and RS contents. As the processed rice is consumed; among the rice varieties and the processing methods, consuming presoaked *Periyavellai* rice variety cooked without draining excess water could be recommended to have more RS.

Keywords: Improved rice varieties, Resistant starch, Sri Lankan rice varieties, Traditional rice varieties

Food Security and Food Safety

Analytical Determination of Terephthalic Acid and Isophthalic Acid Migration into Deep Fried Crispy Snacks through Adulterated Edible Oils – Method Development and Validation

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Non-branded deep fried manioc chips were evaluated by following a newly developed and validated method to determine the migration of Terephthalic acid (TPA) and Isophthalic acid (IPA) from the frying oils adulterated with PET bottles to make the snacks crisp and long last. Reporting method was comprised of Soxhlet extraction of oils from 400 deep fried manioc chip samples, solvent extraction of TPA and IPA using centrifuged oil samples, sample preparation for High Performance Liquid Chromatography (HPLC) analysis of samples along with the TPA and IPA standard series. The percentage recovery range for TPA and IPA was in between 80-120% for 20 manioc chip samples fried in edible oils incorporated with PET bottles. The results showed that the specific migration of TPA and IPA into the manioc chip samples conform to European Union legislation that identifies specific migration limits (SML). The intraday assays for TPA and IPA were expressed as Relative Standard Deviation (RSD) 5.123% and 2.015%, respectively while inter-day precision assays for TPA and IPA were expressed as RSD 2.089% and 2.105% respectively. Results highlighted that the data is tightly clustered around the mean with a good precision. Analytical curves for TPA and IPA were found to be linear over a wide concentration range (6 – 120 ppb) with a correlation coefficient of 0.998 for TPA and 0.999 for IPA. The lower limit of quantification was determined to be 6 ppb, with a RSD lower than 10%. TPA and IPA in sample are well separated from each other and from the background oil. The study shows that the method presented in the methodology can be used as a suitable method for analytical determination of TPA and IPA in deep fried crispy snacks like manioc chips with high precision and accuracy.

Keywords: Adulterated edible oils, Deep fried manioc chips, Isophthalic acid, Migration, Terphthalic acid

Comparative Study on Stability of Coconut Oil, Sunflower Oil and Palm Oil During Deep Frying

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Repeated use of oils for frying can create products that are harmful for human health. This study was aimed to evaluate the stability of three oils widely used in Sri Lanka, namely, coconut oil (CO), sunflower oil (SO) and palm oil (PO) during continuous deep frying. Oil samples were purchased from local markets. Frying experiment was conducted by frying potato slices at 175±5 °C. Frying was done for 15 minutes (one frying cycle). This process was conducted over a period of 12 hours using the same oil without replenishment. Samples were collected after every two hours during frying and evaluated for the chemical changes [acid value (AV), iodine value (IV)and total polar compounds (TPC)] and physical changes (viscosity and smoke point) occurred during frying. Oxidative stability of oil samples were determined by evaluation of peroxide value (PV), *p*-anisidine value (*p*-AV) and conjugated dienes (CD) and conjugated trienes (CT) values. Data were statistically analysed using ANOVA ($\alpha = 0.05$) using SAS. Less changes were observed in the parameters determined for the CO than SO and PO. Rates of increase in AV (0.02/hour), *p*-AV (8.03/hour), PO (0.13/hour) and viscosity (1.15/hour) were higher for SO than other oils. Smoke point of all oils decreased significantly, however, the reduction was higher for PO (from 208.5 °C to 172 °C) than others. TPC were increased significantly during frying in all three oils. However, TPC of CO did not reach the maximum acceptable limit (24-27%) throughout the frying, while, PO and SO reached the limit at 4 and 12 hours of frying, respectively. The rate of reduction in the IV of the PO and SO was 0.03/hour and 1.15/hour, respectively. Based on the results of this study, it can be concluded that the CO is more suitable for continuous deep frying up to the duration studied compared to other two oils.

Keywords: Coconut oil, Continuous deep frying, Frying cycle, Oxidative stability, Total polar compounds

Effect of Plantain Peel Extract on Oxidative Stability of Coconut Oil and Sesame Oil Blends during Accelerated Oven Storage

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This study was aimed to determine the effect of acetonic extract of plantain peel on oxidative stability of coconut oil and sesame oil blends during accelerated oven storage. Oil blends were prepared to contain different ratios (volume basis) of coconut oil and sesame oil such as 70:30 (blend 1), 50:50 (blend 2) and 30:70 (blend 3), respectively. Level of oxidation of the oils was assessed by measuring free fatty acid content, peroxide value and *p*-anisidine value. Plantain peel extract was incorporated at 800 ppm into the oils. Oil sample without any added antioxidants was used as negative control, whereas, oil samples added with Butylated Hydroxytoluene (BHT) (200 ppm) and tocopherol (200 ppm) were used as positive controls. Accelerated oven storage test was carried out by keeping samples in an oven at 60±5 °C up to 14 days and samples were analyzed on 1st, 3rd, 7th and 14th days of storage. Data were analysed (α = 0.05) using SAS. The free fatty acid content, peroxide value and *p*-anisidine value of all oil samples expressed a gradual increase throughout the storage up to 14 days. The oil samples added with plantain peel extract exhibited significantly lower free fatty acid content, peroxide value and *p*-anisidine value than both positive controls and negative control throughout the storage. Among the blends, blend 1 showed significantly higher oxidative stability than other two blends and it exhibited shelf life comparable to coconut oil, but significantly higher than that of sesame oil. From this study, it is concluded that the plantain peel extract could be more effective than synthetic antioxidants (BHT and tocopherol) in improving the oxidative stability of oil samples during accelerated oven storage.

Keywords: Accelerated oven storage, Antioxidants, Coconut oil, Sesame oil

Evaluation of Effect of Passion Fruit (*Passiflora edulis*) Leaf Extract on Stability of Palm Oil during Heating

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Palm oil is widely used in shops as the frying medium. This study was carried out to evaluate the effect of continuous heating on the quality of the palm oil and the effects of adding passion fruit (*Passiflora edulis*) leaf extract on its stability. Antioxidants were extracted from the leaves using acetone. Negative control (samples without any added antioxidants), positive control [samples added with 200 ppm of Butylated Hydroxytoluene (BHT)] and test (samples added with 1000 ppm of extract) samples were prepared. All oil samples were evaluated for their stability during continuous heating by heating the oil at 170±5 °C up to 24 h (30 min heating followed by 30 min cooling). The level of oxidation of the samples was determined by evaluation of peroxide value, *p*-anisidine value, TOTOX value, free fatty acid content, total polar compounds and fatty acid composition and conjugated diene (CD) and conjugated triene (CT) values. The data were analysed by performing ANOVA ($\alpha = 0.05$) using SAS. The free fatty acid content of the oil before heating was significantly higher (44.76±0.09%) than the standard value (5%) indicating that the oil has undergone extensive hydrolysis already. All parameters measured were increased in all three samples, however, free fatty acid content, peroxide value, *p*-anisidine value and CD and CT values were significantly less in the test samples than positive control and negative control. The average rate of formation of polar compounds (% increase per heating cycle) was significantly less in the test sample (1.29%) and positive control (1.27%) than negative control (1.68%). These results indicate that passion fruit leaf extract (1000 ppm) can more effectively control thermal oxidation of palm oil than BHT during continuous heating. This study shows that the fresh passion fruit leaf extract could be used as a potential source of antioxidant to improve the oxidative stability of edible oils.

Keywords: Antioxidant, Continuous heating, Palm oil, Passion fruit leaf extract, Thermal stability

Quality Analysis of Selected Commercially Available Reverse Osmosis Treated Drinking Water Samples in Jaffna District

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The trend in choice of drinking water in Jaffna district has been changing from groundwater to Reverse Osmosis (RO) treated water. Therefore, this study was aimed to evaluate the quality of selected RO treated water samples available in Jaffna District, Sri Lanka. Randomly selected ten commercially available RO treated water samples were collected for water quality testing. The water quality analysis includes physiochemical parameters (pH, electrical conductivity, total dissolved solids, total suspended solids, turbidity, color, odor, taste, iron, nitrate, nitrite, sodium, potassium, total hardness, magnesium, calcium, alkalinity, and chloride) and microbiological parameter (Total bacterial count). The measured water quality parameters were compared with the Sri Lankan Standards (SLS). The results showed that all parameters of all samples except pH were below the maximum permissible levels; electrical conductivity -45.5 µs/cm – 151.97 µs/cm (permitted level < 750 µs/cm), total dissolved solids -15.38 – 82.35 mg/L (permitted level < 400 mg/L), total suspended solids -0 mg/L, turbidity -0.067 – 0.2117 NTU (permitted level < 2 NTU), color (colorless), odor (odorless), taste (tasteless), iron - 0.003 – 0.17mg/L (permitted level < 0.3 mg/L), nitrate -0.28 – 1.51mg/L (permitted level - 50 mg/L), nitrite -0 – 0.004 mg/L (permitted level < 3 mg/L), sodium -0.8 – 13.35 mg/L (permitted level <200 mg/L), potassium - 0.27 – 1.50 mg/L (permitted level <20 mg/L), total hardness - 4.81 – 10.63 mg/L (permitted level < 400 mg/L), magnesium -1.64 – 4.97 mg/L (permitted level <150 mg/L), calcium 1.7 – 13.2 mg/L (permitted level <100 mg/L), alkalinity 83.33 – 173.33 mg/L (permitted level <400 mg/L) and chloride -30.76-72.18 mg/L (permitted level < 200 mg /L). The pH of most samples (5.6 – 6.9) was below the permissible level (6.5 – 8.5). The mineral and ion contents of most samples were well below the maximum permissible level. This may be due to the elimination of minerals and ions during the reverse osmosis process. The analysis of microbial quality of all samples showed colony development after 24 hours. Therefore, proper sanitation practices and processing methods should be followed to enhance the microbial quality of the samples. Further studies are needed to quantify the mineral level in the RO treated water and to solve the acidity issues in RO treated water.

Keywords: Drinking water, Quality parameters, Reverse osmosis, Sri Lankan Standards

Livestock, Aquaculture and Fisheries

Comparison of Nutritive Value in Fodder Species and Industrial By- Products Available in Low Country Dry Zone (DL1b- Anuradhapura District), Sri Lanka

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This experiment intended to find out the nutritive value of fodder species and industrial by-products available for feeding ruminants in Anuradhapura district. Fodder species; maize (*Zea mays*), sorghum (*Sorghum bicolour*), CO-3 (*Pennisetum purpureum* x *P. americanum*), gliricidia (*Gliricidia sepium*), and guinea grass (*Panicum maximum*) and agro-industrial by-products; rice (*Oryza sativa*) bran, coconut (*Cocos nucifera*) poonac, maize (*Zea mays* L.) meal and soya bean (*Glycine max*) meal (SBM) were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), ash, acid detergent fiber (ADF), neutral detergent fiber (NDF) and gross energy (GE). Nitrogen free extract (NFE), total digestible nutrients (TDN) and metabolizable energy (ME) were calculated. The data were analysed using one-way ANOVA procedure in SAS. The observed TDN, ME and GE of fodder species differed significantly ($p<0.05$). Gliricidia obtained the highest ($p<0.05$) percentage of DM (25.10±0.78), EE (3.96±0.62), CP (23.79±0.41), TDN (64.34±1.40) and GE (4060±5.54 kcal/g) and ME (2420±0.26 kcal/kg). Guinea grass contained the highest ($p<0.05$) percentage of ADF (46.78±3.25) and NDF (71.15±1.96) compared to other fodder species. Sorghum and CO-3 had the highest ($p<0.05$) percentage of ash (10.21±1.77) and CF (36.70±2.94) while the lowest ($p<0.05$) percentage of ash and CF were recorded in maize (7.77±0.44) and gliricidia (26.37±5.48), respectively. When considering the agro-industrial by-products, highest ($p<0.05$) percentage of total ash (8.52±0.79), CP (50.99±0.43), TDN (83.50±2.09) and ME (3280±0.39 kcal/kg) were reported in SBM while NFE (83.08±1.22%) was highest in maize meal. The highest ($p<0.05$) percentage of EE and GE were obtained from rice bran. Thus, the results of the current study show that the above feed ingredients available in Anuradhapura district are rich in nutrients needed for dairy cows and that they can be effectively incorporated in the formulation of total mixed rations for dairy cows.

Keywords: Agro-industrial by-products, Fodder species, Gross energy, Nutrient comparison

Morphometric Variation Analysis of Black Tiger Shrimp (*Penaeus monodon*) Brood Stock Collected from Two Sites in Sri Lanka

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Penaeid shrimps consist of approximately 110 species of which about 10 species are important for commercial culture. In Sri Lanka, *Penaeus monodon* species are found naturally in the coastal areas around the country and, matured wild caught shrimps are used as the brood stock in shrimp aquaculture industry. Morphometric differences among stocks of a species are recognized as important tool in evaluating the population structure. This study investigated the variation of morphological characters among *P. monodon* stocks collected from two different geographical areas of Sri Lanka; east coast (Batticaloa, n=58) and west coast (Chilaw, n=52). Truss network analysis of twelve measurements were standardized with equation $LTs_{(i)} = \log_{10} LT_{(i)}[\log10\ TLm / \log10\ TL_{(i)}]b$. Principal component analysis (PCA) was performed to test morphological variations within stocks. Wilks' Lambda test revealed that there are significant difference in all morphometric variables between east and west coasts (Wilk's $\lambda = 0.11233$, $F(12, 95) = 62.562$ and $p < 0.05$). Two principal components derived from PCA analysis accounted a total of 65% variance in truss measurement data. The plot against first (PC1) and second principal components (PC2) scores showed heterogeneous stock structure in east and west coast of Sri Lanka. Present finding is important for the brood stock development programs and uplift knowledge of phenotype of the *P. monodon* species. Studies on population genetics are recommended to confirm the results of the present study.

Keywords: Morphological characters, *Penaeus monodon*, Stock structure, Truss network

Cross Sectional Study of Gastrointestinal Parasitism of Cattle in Kilinochchi District

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Gastrointestinal parasitism is a condition caused by the gastrointestinal parasites. It is a major impediment to livestock production. It has negative impact on economy of farms by causing mortality and losses in body weight gain, growth, production and condemnation of carcasses. A cross sectional study was carried out at cattle farms in Kilinochchi district to determine the prevalence of gastrointestinal parasites of cattle from January 2020 to July 2020. A randomly selected 106 cattle were examined using standard coprological examination. The faecal samples were screened for gastrointestinal parasitic eggs by McMaster and simple sedimentation test. The positive samples were subjected to egg morphological identification of prevalent gastrointestinal parasitic species. The results showed 15.10% (n=16) of cattle were moderately infested by gastrointestinal parasites and 84.90% (n=90) of cattle were highly infested by gastrointestinal parasites. In this study area most of the cattle (94.30%, n=100) were infested by more than one parasite species (Multiple parasites infestation) while 5.70% (n=6) of cattle had single parasite infestation. The eggs of nematodes (85.95%), trematodes (9.03%) and oocysts of protozoans (5.02%) were observed in this study area. The *Ascaris* sp (84.00%, n=89) was common parasite found in all four veterinary regions. Other species such as *Strongyle* sp. (77.40%, n=82), *Strongyloides* sp. (72.60%, n=77), *Paramphistomum* sp. (25.50%, n=27), *Eimeria* sp. (14.20%, n=18) and *Trichostrongylus* sp (8.50%, n=9) were also found. The *Eimeria* sp., *Paramphistomum* sp. and *Trichostrongylus* sp. were highly observed in cross breed than the local breed. The *Ascaris* sp., *Strongylus* sp. and *Strongyloides* sp. widely found in local breed. The higher infestation was recorded in Kandawalai veterinary region (96.00%) while lowest infestation observed in Karachchi veterinary region (71.42%). The *Trichostrongylus* sp. and *Paramphistome* sp. were not found in Pachilapalli veterinary region.

Keywords: Coprological examination, Egg morphology, Gastrointestinal parasitism, Kilinochchi district

Potentials and Challenges in Expanding Inland Fishery in Dambe-ara, Wellawaya, Sri Lanka

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Overexploitation of marine resources claims extensive attention on inland fisheries. Monaragala is one of the districts with copious inland water bodies with a greater potential for employment opportunities, fisheries products, and food security of rural households. Dambe-ara is 80 ha in extent and located in Wallawaya Divisional Secretariat Division (DSD) with a substantial potential to aquaculture fisheries production. However, its contribution and potential are inadequately researched. This paper attempts to unravel potentials and challenges to expand Dambe-ara inland fisheries while exploring its contribution to the region. Qualitative data collection methods were employed. Five key-informant discussions and ten in-depth interviews were administered through a time randomization sampling technique. Respondents, who were operating at the landing site from 9.00 am to 11.00 am were interviewed. Secondary data were obtained through National Aquaculture Development Authority, National Aquatic Resources Research and Development Agency, Ministry of Fisheries and Aquatic Resources Development and other relevant articles. Results revealed that the harvest comprises with 40% *Entroplus suratensis* (Green chromide), 28% *Catla catla* (Catla), 24% *Channa striata* (Mural) and 4% *Hypophthalmichthys molitrix* (Silver carp) and *Cyprinus carpio* (Common carp), 01% *Cirrhinus mrigala* (Mirigal), 02% *Macrobrachium rosenbergii* (Fresh water prawns), and 01% *Labeo rohita* (Rohu). Fishing in Dambe-ara is seasonal where the peak harvest extends from February to July with an average annual yield of 62.5-150 kg/ha. Harvest fluctuates from 9-15 kg/ha during the season and 6.25-12.5 kg/ha in rest of the year. Dried fish processing had been practiced before 2016 but declined due to lack of motivation and incentives. A permanent feeding water source is lacking, whereas, the inactive fisheries association hinder the progression. Despite the higher productivity of the tank, the present situation is woefully affected with poor attention paid by the government. The tank management can obtain 50% contribution from the government out of annual total cost for fish breeding, training, financing and equipment as craft and gill net, yet its operation is dormant. In conclusion, proper attention and patronage from the government, especially through robust institutions is suggested to increase the production that would enhance livelihoods of more than 250 households and animal protein requirement of over 54, 911 people in Wellawaya DSD while contributing to uplift the GDP of the country.

Keywords: Development, Fish resources, Fresh water, Inland fishery

Farmers' Perceptions on Dairy Development Strategies in Vavuniya District, Sri Lanka

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Improving milk production in Northern Province is one of the main constituents of dairy rural life. Dairy farmers confront the challenges such as lack of abandoned land, lack of grazing land, the low success rate of artificial insemination, lack of awareness of new technology and the annual total amount of milk entry to dairy market is not enough. Vavuniya is one of the main milk producing and cattle breeding districts. This study investigates farmer's willingness to pay for different dairy development strategies, their priority among the development strategies and the impact of socioeconomic demographic characters of farmer on the perceptions of dairy development strategies. For this study, 200 farmers were randomly selected from Vavuniya district. Choice modelling was employed and conditional logit models were developed to estimate farmer's willingness to pay for different dairy development strategies. The result of this study indicates that farmers are willing to pay for all dairy development strategies and their priority order among development strategies is as follows: training on silage making, milk collection in morning and evening, milk collection centre within 2 km and increase the success rate of artificial insemination. Farmer's income and education level positively influence the willingness to pay for training on silage making and also farmer's education level has positive impact on the willingness to pay for milk collection in morning and evening. Female farmers are willing to pay more for training on silage making than male farmers. Finding of this study would assist various planners and authorities in formulating suitable dairy development strategies and appropriate fees for the services provided by the Department of Animal Production and Health to increase milk production in Vavuniya district and utilize the services in effective way.

Keywords: Choice Modelling, Conditional Logit Model, Dairy Development strategies

Plant Protection

Eco-friendly Management of Banana Anthracnose (*Colletotrichum musae*) Using Bio-Rationals

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Banana anthracnose caused by *Colletotrichum musae* (Berk. & M.A.Curtis) Arx is the most serious postharvest disease of immature and mature banana fruits, causing a loss of 30-40% of marketable fruits in Asia. The aim of this study was to determine *in-vitro* antifungal activity of aqueous leaf extracts of selected plant species and to test the antagonistic potential of *Trichoderma viride* against *C. musae*. Aqueous leaf extracts were obtained from *Lantana camera*, *Piper betle*, *Azadiracta indica* and *Cinnamomum zeylanicum* and antifungal activity was determined using poison food technique at 5%, 10%, 15% and 20% concentration in potato dextrose agar under *in-vitro* conditions with three replicates. The results revealed that five days of post-inoculation, all four plant species showed stronger antifungal activity against *C. musae* as opposed to the control. Within the selected concentration, 20% aqueous leaf extracts of *L. camera*, *P. betle*, *A. indica*, *C. zeylanicum* showed excellent inhibitory activity against *C. musae*. Complete mycelial growth inhibition of *C. musae* was observed in leaf extracts of *C. zeylanicum* (100%), *P. betle* (100%) followed by *L. camera* (60%). In addition, *T. viride* gave promising results in controlling the growth of *C. musae* in dual culture under *in-vitro* condition (91%). Based on the results, the selected plant aqueous leaf extracts at 20% concentration could be developed and used as an effective bio-rational to manage the post-harvest anthracnose disease in banana. In future *in-vivo* studies are needed to test the efficacy of these bio-rationals under the field conditions.

Keywords: Anthracnose, Bio-agents, Botanicals, *Colletotrichum musae*, *Trichoderma viride*

Efficacy of an Entomopathogenic Fungus, *Lecanicillium lecanii* as a Bio-Control Agent against *Bemisia tabaci* on *Hygrophila corymbosa*

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Whitefly, *Bemisia tabaci* infestation is observed on *Hygrophila corymbosa,* a newly established aquatic plant in Green Farms Ltd., Marawilla, Negombo. This study was carried out to understand the biology of *B. tabaci,* alternative host and the efficacy of *Lecanicillium lecanii* against *B. tabaci.* Eggs, nymphs and adults of *B. tabaci* was reared and studied their development stages and damaging stages. Six life stages of *B. tabaci* are egg, four instars, and the adult. All the life stages of *B. tabaci* occurred on the lower surface of the leaf. Crawler, the first instar had legs and the only mobile instar that moved to feed sites. Nymphs and adults of *B. tabaci* caused infestation on *H. corymbosa. Solanum lycopersicum, Solanum melongena, Capsicum annuum, Crossandra infundibuliformis, Euphorbia pulcherrima* and *Plectranthus scutellarioide* and those identified as alternative hosts for *B. tacbaci*. Under *in-vitro* conditions the *L. lecanii* formulation was used to control *B. tabaci.* All the experiments were designed according to complete randomized design (CRD). Data were statistically analyzed using the SAS package. Significance among the treatments was determined according to Dunnett mean separation test at 95% of a confidence interval. Application of *L. lecanii* suspensions at 1 g/L, 3 g/L, 6 g/L and 10 g/L against *B. tabaci* nymphal stage resulted in 88%, 97%, 97% and 98% mean mortality respectively at 15 days after treatment (DAT). The results also revealed that the percentage of mean mortality of eggs was very less at different concentrations of *L. lecanii.* No mortality had been observed until 9 DAT. Mean mortality of *B. tabaci* eggs at 1 g/L, 3 g/L, 6 g/L and 10 g/L of *L. lecanii* suspension were 8%, 12%, 12%, and 15% respectively at 15 DAT. Application of *L. lecanii* suspension at 2 g/L, 3 g/L and 4 g/L against the nymphal stage of *B. tabaci* has resulted in 97%, 99% and 99% of mean mortality, respectively at 15 DAT. Hence, 3 g/L of *L. lecanii* was the optimum concentration to control *B. tabaci* nymphs under *in-vitro* conditions.

Keywords: *Bemisia tabaci,* Bio-control, *Hygrophila corymposa, Lecanicilium lecanii*

Larvicidal Activity of Leaf Extract of Lime [*Citrus aurantifolia* (Christ.) Swingle] and Synthetic Pesticide Spinosad against Diamond Back Moth, *Plutella xylostella* L. (Lepidoptera: Plutellidae) on Cabbage

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Diamond back moth, *Plutella xylostella* (L.) is one of the major pests of cruciferous crops in Sri Lanka. The larvae feed on the leaves resulting in a severe loss of yield. Long-term application of synthetic pesticides have adverse effects on non-target organisms, ecosystem and human health. Use of plant extracts could be an alternative to synthetic pesticides for insect pest management. This study was aimed to evaluate the potential use of leaf extract of *Citrus aurantifolia* as a larvicide against 3rd instar larvae of *Plutella xylostella* compared to synthetic pesticide Spinosad under laboratory conditions. Methanol leaf extract (MeLE) at 0.05 g/mL, 0.125 g/mL and 0.2 g/mL and aqueous leaf extract (AqLE) at 0.05 g/ml, 0.15 g/mL, and 0.2 g/mL were tested against 3rd instar larva of *P. xylostella* using leaf dipping bio assay. Five larvae were exposed per cabbage leaf discs (6.4 cm diameter) and treated with leaf extracts along with solvent controls (methanol, water and synthetic pesticide). Dead larvae were removed and counted every 24 hours. Survived larvae were reared until adult emergence. This was replicated four times. Data analysis was carried out performing ANOVA using Minitab (ver.17) software. All concentrations of the leaf extracts caused significant ($p<0.05$) larval mortality of *P. xylostella*. Larvicidal effect of leaf extract of *C. aurantifolia* was increased with the increase of concentrations of MeLE and AqLE and time. All the concentrations of MeLE and AqLE showed 60%-95% larval mortality after 72 hours of exposure comparable with solvent controls while all concentrations of synthetic pesticide except 5 g/L showed 100% larval mortality after 24 hours of treatment. Pupal deformities at 0.2 g/mL of MeLE and curled wing adults at 0.2 g/mL of AqLE were also observed. Further field study is needed to confirm the findings. The result of the present study would be useful in promoting research aiming at the development of new agents for insect pest control based on natural products.

Keywords: Cabbage, *Citrus aurantifolia*, Larvicide, Leaf extract, *Plutella xylostella*

Effect of Plant Extracts on Root Knot Nematode *Meloidogyne incognita* (Kofoid & White) Chitwood in Jaffna, Sri Lanka

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Root-knot nematode, *Meloidogyne incognita* is one of the major pests in tomato and it forms galls in plant roots leading to growth retardation and wilting. This study was aimed to manage *M. incognita* using plant extracts as an alternative to the application of synthetic chemicals. Leaves of locally available underutilized plants such as *Ocimum basilicum, Moringa oleifera, Aegle marmelos, Cassia fistula* and *Azadirachta indica* were tested against *M. incognita*. During the *in-vitro* experiment, *M. incognita* second stage juveniles were exposed to 25%, 50% and 100% concentrations of aqueous extracts of plant leaves. The results revealed that 100% concentration of plant extracts at 48 hours exposure was highly toxic against the survival of *M. incognita* second stage juveniles than other concentration of plant extracts and exposure time. Maximum mortality (90.25%) was achieved in 100% of *A. marmelos* after 48 hours of time. In pot experiment all the plant extracts showed promising results inhibiting gall formation with varying degrees which was statistically significant ($p<0.05$). The extent of galls in *M. oleifera* was significantly less (12.33) in plant extracts treatments ($p<0.05$). The highest shoot height of tomato was achieved in *M. oleifera* (19.33±0.71 cm), followed by *A. indica* (15.97±0.49 cm), *C. fistula* (15.87±0.55 cm), *A. marmelos* (14.43±1.03 cm) and *O. basillicum* (12.23±0.84 cm), receptively. Plant extracts treated tomato showed significantly higher root length whereas maximum root length of 37± 0.44 cm was achieved in *A. indica* followed by *A. marmelos* (3.1± 0.2 cm) ($p<0.05$). The study has concluded that *M. oleifera* leaf extract can be used for management of *M. incognita.* In future, investigation on the different concentrations of plant extracts on inhibition of root galls with highest shoot height and yield is suggested.

Keywords: *M. incognita*, Plant extracts, Root gall, Root knot nematode, Tomato

Exploitation of Phyllospheric and Rhizospheric Microorganisms as Biological Control Agents against *Colletotrichum gloeosporioides* Causing Anthracnose Disease of Mango

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Postharvest decay in harvested fruits and vegetables causes considerable economic losses. Synthetic chemicals are the primary means to control these losses. With the rising concerns on food security and food safety, chemical applications for the control of postharvest diseases are now being questioned. Biological control has become an effective and promising alternative to overcome and environmentally friendly alternative for those adverse effects caused by synthetic chemicals. Therefore, this study was conducted to explore the potential biological control agents in the mango bio-system mainly targeting the phyllosphere and rhizosphere. Leaves, stem parts, inflorescence, and fruits of mango from different locations in Anuradhapura District and soils from organically maintained orchards and home gardens were used for the isolation of microorganisms to be tested for potential antagonism against *Colletotrichum gloeosporioides* (Cg) causing anthracnose disease in mango. Potato Dextrose Agar (PDA), Nutrient Agar (NA), King's B, Yeast Mannitol Agar with Congo Red (YEPD) and Liquid Glucose Medium have been used for the isolations. Identification of the isolates was done observing colony and spore morphologies and bioassays. So far, bacteria (28), fungi (14) and yeasts (08) were found and all the isolates were tested against *C. gloeosporioides* for the biocontrol efficacy using dual culture technique. Cell suspensions of bacterial isolates and spore suspensions of fungal isolates at a concentration of 10^6 CFU/mL as a dip application were used for *in-vivo* experiments. Six treatments including T_1 (Cg + yeast iso 02), T_2 (Cg+ fungi iso 07), T_3 (Cg+fungi iso 12), T_4 (Cg+ bacteria iso 03), T_5 (Cg+ bacteria iso 05) and T_6 (control treatment with sterile distilled water) with three replicates to each treatment were used in *in-vivo* studies. From the isolates, one yeast, two fungal and two bacterial isolates showed potential antagonism against *C. gloeosporioides in-vitro* but none of them showed significant control over *C. gloeosporioides* in *in-vivo* experiments in variety Karaththakolomban. Percentage inhibition (PI) of the 06 treatments in *in-vivo* experiment is 2.17 ± 0.15^a for T_1, 2.57 ± 0.40^a for T_2, 2.55 ± 0.07^a for T_3, 2.43 ± 0.12^a for T_4, 2.53 ± 0.06^a for T_5 and 2.60 ± 0.35^a for T_6.

Keywords: Anthracnose, Biological control, *Colletotrichum gloeosporioides*, Mango, Postharvest decay

Postharvest Technology and Food Biotechnology

Optimization of Bioethanol Production from *Chara globularis* Using *Saccharomyces cerevisiae*

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Ethanol is one of the important alternative energy sources to fossil fuels. Since Sri Lanka has a huge amount of inland water resources and plenty of diverse under-utilized flora which are rich in cellulosic substrates, the possibility of using inland plant resources as substrates for bioethanol production is being researched. This study was aimed to comparatively assess the ethanol production from different fresh water flora in the Northern Province of Sri Lanka and to optimize the conditions for a higher yield from selective spp. Fresh water flora such as *Chara globularis*, *Salvinia, Wolffia*, *Spirodela polyrhiza, Lemna minor*, and *Cabomba caroliniana* were used as substrates for ethanol production using baker's yeast, *Saccharomyces cerevisiae*, in a liquid fermentation system. Thirty grams of dried plant samples were treated with 50 mL of 3% (v/v) H_2SO_4 for 15 minutes and the amount of ethanol produced was determined using an ebulliometer. Among the plant substrates used, a significantly higher amount of bioethanol (0.25%) was produced from *C. globularis*. Thus *C. globularis* was selected for further studies. When *C. globularis* was pretreated with 50 mL of different 3% (w/v) alkaline solutions (NaOH and KOH) and 3% (v/v) acid solutions (H_2SO_4, HNO_3 and HCl), a significantly higher amount of ethanol (0.25%) was obtained with 3% H_2SO_4. Therefore, H_2SO_4 was selected as the best hydrolyzing agent for further study. When H_2SO_4 pretreating concentration (1-10%) was optimized, a significantly higher yield of ethanol (0.3%) was obtained at 4% H_2SO_4. When *C. globularis* was acid hydrolyzed for different time periods (15 min, 30 min and 45 min), a significantly higher ethanol yield (0.4%) was obtained at 30 min incubation period. When the amount of ethanol produced by *C. globularis* pretreated with 50 mL of 4% H_2SO_4 for 30 minutes was measured at every 12 hours, the highest amount of ethanol (0.5%) was produced at 60 hours of fermentation time. When fermentation was carried out with baker's yeast inoculated peptone, yeast extract and nutrient (PYN) medium at room temperature and pH 7.0 and under the optimized conditions, the amount of ethanol produced from *C. globularis* was two times higher than the non-optimized conditions. Further optimization studies are underway in order to enhance the final ethanol yield.

Keywords: Bioethanol, *Chara globularis,* Fermentation, Pretreatment, *Saccharomyces cerevisiae*

Effect of Natural Edible Coatings on Quality Characteristics and Storage Behaviour of Mango (*Mangifera indica* L.) during Cold Storage Conditions

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Mango is an economically important seasonal fruit facing greater problems in storage and transportation to long distance market because of its perishable nature. Natural edible coatings have been proved for enhancing shelf life, delaying the ripening and preserving the quality of fruits. Hence, this study was carried out in the Laboratory of National Institute of Post Harvest Management to identify the effect of applying IPHT bio wax (IPHT) 1:25, Chitosan (CH) 0.8% and Gum Arabic (GA) 8% on delaying ripening, enhancing the storage life and retaining the quality of mango fruits cv. *Karuthakolomban* during cold storage as complete randomized design (CRD) with three replicates where the data were assessed by the analysis of variance (ANOVA). As measurements, storage life, juice pH, total soluble solids (TSS), fruit firmness, peel colour of L*, a* and b* values and titratable acidity (TA) were investigated. Mango fruits harvested at physiological maturity were treated with the selected wax treatments and stored under cold room conditions (13±1°C, 90% RH) and measurements were taken with five days interval during the storage period. CH, GA, IPHT and control samples showed storage life of 27, 23, 24 and 18 days, respectively. Significant differences were observed ($p<0.05$) for tested parameters for CH, GA and IPHT bio wax compared to the control. There were no significant differences ($p>0.05$) observed between GA and IPHT for tested parameters. At the latter stage of storage, there were significant differences ($p<0.05$) observed between CH and other treatments for pH, TSS, firmness and peel colour values. Experimental results suggested that application of Chitosan 0.8%, Gum Arabic 8% and IPHT bio wax 1:25 coating as bio preservative is an effective technique for extending the storage life and maintaining the quality of mango fruits during cold storage where Chitosan 0.8% was selected as the best treatment.

Keywords: Chitosan, Gum Arabic, IPHT bio wax, Mango, Postharvest

Isolation of Lactic Acid Bacteria from *Idli* Batter and Assessing their Antibacterial Potential

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Idli is one of the flour-based fermented foods that can potentially contain probiotic lactic acid bacteria. This study was designed to isolate and determine antibacterial activity of lactic acid bacteria from *Idli* batter, identify the acidity changes of *Idli* batter and sensory quality changes of *Idli* with fermentation time up to 32 h. Lactic acid bacteria were isolated from *Idli* batter and characterized to genus level by biochemical tests. Agar well diffusion assay was carried out to determine the antibacterial activity of isolates against food borne pathogens; *Salmonella enterica*, *Escherichia coli* and *Staphylococcus aureus*. With fermentation, changes of pH, Lactic acid bacterial count, titratable acidity and sensory quality of final product were measured. In overall, ten isolates were recognized from *Idli* batter, of which, six were rod shaped, Gram positive, non-motile, non-spore formers and negative to catalase activity, belonging to *Lactobacillus* spp. Other 4 isolates were cocci shaped, Gram positive, non-motile, non-spore formers and negative to catalase activity, belonging to *Lactococcus* spp. On the basis of zone of inhibition, among ten isolates, isolate I-6 was considered as the highest potential bacteriocinogenic isolate against all test organisms. The overall zone of inhibition diameter of isolates fell within range from 7.3±1.53 to 16.3±0.58 mm. The pH dropped steadily from 6.28 to 3.72, while titratable, acidity increased from 0.24% to 0.92% during the period of 0 to 32 h. With fermentation time, the lactic acid bacterial count was increased and higher lactic acid bacterial count of 9.88 $\log_{10}$cfu/g was observed after 12 h of fermentation and the count was reduced with increasing acidity. *Idli* prepared from *idli* batter after 8-12 h of fermentation scored maximum for the sensory quality. *Lactobacilli* spp are the predominant Lactic acid microbial group involved in natural *Idli* batter fermentation which have anti-microbial activity against food pathogens.

Keywords: Anti-microbial activity, Biochemicals, *Idli* batter, Lactic acid bacteria, Sensory quality

Evaluation of the Effectiveness of Modified Atmospheric Packaging on Postharvest Life of Curry Leaves (*Murraya koenigii* L.)

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Curry leaves (*Murraya koenigii* L.) is a popular leafy spice, leafy vegetable and medicinal plant which is being used for culinary purposes as well as medicinal treatments. However, postharvest shelf life (PSL) under ambient condition (31.64±1.84 ºC; 53.21±9.40 RH) is around two days. Modified atmospheric packaging (MAP) has been used as an effective method to extend the PSL of perishables including leafy vegetables. Therefore, present study was conducted to evaluate the effectiveness of MAP on PSL of curry leaves at the laboratory of National Institute of Post-Harvest Management, Anuradhapura. Curry leaves were harvested from Anuradhapura district. Experiment was conducted as completely randomized design with three replicates and data were analyzed using ANOVA. Four treatments were used where, T1 (Sealed polyethylene (SPE) bags of gauge 150), T2 (Perforated polyethylene (PPE) bags of gauge 150), T3 (SPE bags of gauge 300), T4 (PPE bags of gauge 300) and CR (control treatment without a package). Curry leaves (compound leaves) of 30 g bundles were used per treatment. As measurements, leaf color values (L*, a* and b*), leaf defoliation percentage (defoliation of leaflets from compound leaf), physiological weight loss (PWL), chlorophyll content and total carotene content were measured. Leaf color values and physiological weight loss of control samples were significantly different (p<0.05) compared to other treatments. Chlorophyll content was significantly different (p<0.05) among the treatments, no significant difference (p>0.05) was observed for total carotene content. Control samples showed two days of PSL where completely dried out at 3rd day of storage. Irrespective of thickness, PPE packages extended the shelf life for 4 days which was 100% increment of PSL. SPE packages of gauge 300, showed one day of storage life where it produced unpleasant odor at 2nd day of storage. SPE packages of gauge 150, extended the shelf life up to 6 days which was 200% increment of PSL. It can be concluded that SPE packages of gauge 150 can be used to extend the postharvest shelf life of curry leaves.

Keywords: Leafy spice, Modified atmospheric packaging, Postharvest technology, Postharvest loss

Development of an Artificial Ripening Protocol for Cultivated Variety of "Karuthakolomban" Mango (*Mangifera indica* L.) Available in Anuradhapura District, Sri Lanka

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Mango (*Mangifera indica* L.) is one of the widely cultivated fruit crops in the dry zone of Sri Lanka. This study aimed to develop an artificial ripening protocol for mango cultivated variety "Karuthakolomban" available in Anuradhapura district, Sri Lanka, using Ethephon (2-chloroethyl phosphonic acid) at different levels of concentration as a ripening agent to reduce post-harvest losses in destination markets. Selected mangoes were treated with Ethephon at three levels of concentrations (100, 150 and 200 ppm) and exposure times (12, 18 and 24 hours) in an artificial ripening chamber. The experiment was carried out at 30±2 °C for 5 days up to ripening of mangoes. Untreated samples were used as control and kept for 5 days under similar conditions. During the ripening, physiochemical parameters of fruits were analyzed continuously for 5 days during storage. The treatment which exposed to 100 ppm at 12 hours Ethephon showed a gradual decrease of firmness (5.59±0.43 N) and titratable acidity (0.5±0.06%) and total chlorophyll content (8.1±0.28 mg/L), whereas, some parameters, showed an increasing trend such as total soluble solids (19±0.8%), fructose (6.68±0.14 mg), sucrose (13.94±0.09 mg), ethylene emission (310.13±0.1 ppm), peel and flesh color (L*- 68.12±0.01, a*-1.25±0.98, b*-40.63±0.9), pH (3.5±0.06), and weight loss percentage (5.27±0.75%). Sensory evaluation was carried out to check the parameters such as peel and flesh color, taste, aroma, texture and overall acceptability using 30 untrained panelists by using 5 point hedonic scales. Samples treated with 100 ppm Ethephon for 12 hours of exposure time exhibited the highest overall acceptability (92.5) compared to 150 and 200 ppm Ethephon dosages. Furthermore, 100 ppm dosage Ethephon treated samples with 12 hours of exposure time attained their marketable stage within 3 days compared to other treatments. Therefore, this study revealed that 100 ppm Ethephon dosage for 12 hours of exposure time is the best treatment for ripening of mango variety "Karuthakolomban" to safeguarding quality and storability.

Keywords: Artificial ripening, Ethephon, Exposure period, Mango

Shade Curing Reduce the Postharvest Loss of Big Onion (*Allium cepa*) Selection 'Dambulla Red' at Ambient Storage Conditions

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Big onion (*Allium cepa*) is considered as a high value cash crop in Sri Lanka, where it is one of the largely consumed condiment. However, big onions are subjected to high postharvest losses during the storage period due to many reasons even though it is a semi-perishable crop. One of the major reasons is improper or no curing before or after harvesting. Major reason for improper or no curing is the rainy weather condition prevailed during the harvesting period. Therefore, this experiment was conducted to evaluate the effectiveness of shade curing as an alternative to field curing. Hence, shade curing and field curing (control treatment) considered as treatments with complete randomized design and three replicates were used. Onions were harvested from selected fields in Anuradhapura district. As measurements, Physiological weight loss (PWL), Rotting Percentage (RP), Sprouting percentage (SP), Total Soluble Solids (TSS), and Total Post-harvest Loss (TPL) were recorded at two weeks intervals for three months. PWL was higher at field cured samples where it was significantly different ($p<0.05$) after 1st, 2nd, and 3rd months of storage period compared to shade cured samples. PWL of field cured and shade cured onions after three months of storage were 12.62±1.62 and 8.04±1.6%, respectively. No significant differences ($p>0.05$) were observed for TSS, RP and SP between treatments. Total postharvest loss was significantly different ($p<0.05$) between two treatments where it was 9.15% and 13.7% for shade cured and field cured onions, respectively. Therefore, the results of the present study emphasized that the shade curing can be considered as an appropriate and important alternative method over conventional field curing. However, further research activities should be planned to reduce the storage loss of big onion through artificial curing coupled with controlling the relative humidity and temperature conditions during the storage period.

Keywords: Big onion, Condiment, Curing, Postharvest loss, Shelf life

Production of Single Cell Protein from Underutilized Seaweed *Turbinaria* spp. Using Mixed Culture of Palmyrah Toddy

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Due to the steep increasing global population, the demand for protein increases day by day. To overcome the protein shortage, single cell protein (SCP) is used as a protein supplement for human and animals. This study was aimed to produce SCP from the extracts of underutilized, abundantly found marine seaweed, *Turbinaria* spp. as the substrate, using the mixed culture of organisms grown in palmyrah (*Borassus flabellifer*) toddy. *Turbinaria* spp. were collected, sundried, ground to a powder form and *Turbinaria* solution was prepared by mixing distilled water and this was used as a growth medium throughout the experiment without adding any supplements. This medium [10 g *Turbinaria* spp. powder in 100 mL water (10% w/v)] was inoculated with 10 mL natural palmyrah toddy and allowed to submerged fermentation at 29 °C for 72 h which yielded a crude protein of 38.5% (w/v). When the growth temperature was optimized at 35 °C (43.4%), SCP yield was significantly increased by 1.36 times than the initial non- optimized temperature 27 °C (32.7%). When fermentation period was optimized as 48 h (44.33%), SCP yield was significantly increased by 1.14 times than the initial non- optimized time (24 h-38.55%). *Turbinaria* spp. medium and inoculum ratio was optimized as 50:10 (43.7%), for higher SCP yield. When initial pH of the medium was set at 6.0, significantly higher relative SCP was produced. Amino acid analysis revealed that the SCP produced in the *Turbinaria* medium had all the essential amino acids with significantly higher amount of methionine (3.9%) and lower amount of threonine (0.2%). Vitamin B analysis revealed that SCP yield in the *Turbinaria* medium contained thiamin (0.85 mg/100g) and riboflavin (3.2 mg/100g). After the optimization of growing conditions and media composition, SCP production in the medium containing under-utilized seaweed *Turbinaria*, increased by 1.13 times (from 38.5% to 43.7%).

Keywords: Crude protein, Single Cell Protein, Submerged fermentation, *Turbinaria*

Soil Science and Nutrient Management

Mapping Soil pH and Electrical Conductivity of Sugarcane (*Saccharam officinarum*) Land Using Arc GIS in Gal-Oya Plantation, Ampara, Sri Lanka

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Gal-Oya plantation (2750 ha) is one of the main sugarcane growers in Ampara district. The yield produced by the plants depends on several soil parameters. Objective of this study was to evaluate and map the soil pH and electrical conductivity (EC) distribution in the fields of Gal-Oya plantation and to examine the influence of pH and EC on crop yield. For the experiment, a total of 306 soil samples were collected at 15 cm and 40 cm depths from 49 blocks in the field. The GPS locations of the sample points were recorded. Soil pH and EC values were measured by using OHAUS Model ST300 meter. Soil texture was analyzed by using hydrometer method. Arc GIS 10.5 software and Google Earth Pro were used for spatial analysis. Soil pH and EC distribution map was developed by using Inverse Distance Weighting (IDW) interpolation method. The results showed that the, soil pH and EC do not have a significant influence ($\alpha = 0.05$) on the sugarcane yield of the study area. Soil pH at 15 cm and 40 cm depths were in the range of 5.7-7.3 and 5.8-7.8, respectively. The soil EC at 15 cm and 40 cm depths were in the range of 13.7 - 81.2 µS/cm and 12.2-109.8 µS/cm, respectively. Soil pH at 15 cm and 40 cm depths had a positive correlation. Soil EC at 15 cm and 40 cm depths has a positive correlation as well. Gal-Oya Plantations consist sandy to clay loam soils according to the analysis. The organic matter content in the study area is relatively low (0.052% to 3.219%) and may lead to nutrient deficiencies and poor soil physical properties.

Keywords: Arc GIS, Inverse Distance Weighting, Organic matter, Soil EC, Soil pH

Formulation of Organic Liquid Fertilizers and their Effects on Germination of Selected Seeds and Growth and Yield of Chilli (*Capsicum frutescens* L.)

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The present study was aimed to formulate organic liquid fertilizers using banana pseudostem and to assess their potential use in the germination of selected seeds (i.e., chilli, curry chilli, lettuce and water spinach), and growth and yield of chilli (*Capsicum frutescens* L.), in combination with either organic (cattle manure-CM) or inorganic fertilizers (IF).The experiment was conducted at Department of Agricultural Chemistry, University of Jaffna during January to June 2020. The formulations were banana pseudostem extract with decomposed solution (banana formulation- BF) and banana pseudostem extract with 2% Panchagavya (BP). Nutrient content (NPK) of formulations were analysed. In the germination test, control (distilled water. T1), was compared with BF (T2) and BP (T3). The pot experiment was conducted in a complete randomized design with six treatments and four replicates. The treatments were T1 (100% IF), T2 (100% CM), T3 (50% IF + 50% BF), T4 (50% CM + 50% BF), T5 (50% IF + 50% BP) and T6 (50% CM + 50% BP). The liquid formulations were applied at the rate of 250 Lha^{-1}. Growth parameters namely number of leaves and plant height and yield were measured. Data were statistically analysed using ANOVA and mean separation was done using DMRT. Results of nutrient analysis of formulations indicate that BF had 365 ppm N, 1320 ppm P and 8097 ppm K, while BP had 601 ppm N, 1930 ppm P and 8619 ppm K. The results indicated that the highest germination percentage was recorded in T2 (BF) in all selected seeds. Vigour index was higher in T2 (BF) and T3 (BP) treatments than the control. Significant differences were only observed among treatments in plant height of chilli at the second and sixth week. However number of leaves showed significant differences during the second, fourth and sixth weeks. Among the treatments, the highest yield was recorded in T6. Moreover, all foliar treatments T3, T4, T5 and T6 performed better than T1. By substituting 50% of inorganic fertilizer with banana liquid formulations, the yield of chilli was increased by 46%.

Keywords: Banana formulation, Banana pseudostem extract, *Capsicum frutescens*, Panchagavya

Effect of Gypsum Application on Yield Performance of Ground Nut (*Arachis hypogea* L.) Varieties in Kilinochchi District, Sri Lanka

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Groundnut (*Arachis hypogea* L.) is an important oil crop grown in Sri Lanka. Application of fertilizer is substantially contributing to the yield increment; however improper management of fertilizer and minerals is the specific drawback in the production of good quality and yield in groundnut. To overcome this problem, the application of balanced fertilizer and minerals play a crucial role in the cultivation of ground nut. An experiment was conducted at the Department of Agronomy, Faculty of Agriculture, Kilinochchi to assess the effect of different rates of gypsum application on yield performance of groundnut varieties during the period of January to May 2019. Two factor factorial experiment was conducted in Randomized Complete Block Design (RCBD) with three replications. Four different rates of gypsum application such as 0 kg/ha (T_1 - control), 75 kg/ha (T_2), l25 kg/ha (T_3) and 175 kg/ha (T_4) were used as the first factor and five groundnut varieties, namely Tissa (V_1), Lanka Jumbo (V_2), Tikiri (V_3), Indi (V_4), and ANK G1 (V_5) were used as the second factor. All the agronomic practices were done according to the recommendations of the Department of Agriculture. The yield parameters recorded and shelling percentage was calculated. Data were analyzed by using SAS 9.1 package to perform ANOVA. Best treatment was identified through the means separation by using Duncan's Multiple Range Test at p = 0.05. The yield parameters of fresh and dry weight of pods / plant, hundred pods and seeds weight, number of mature and immature pods and total yield were higher in gypsum applied treatments rather than control and the highest in T_4 (175 kg/ha gypsum) treatment. All the yield parameters were significantly different in Lanka Jumbo and ANK G1 from other varieties. However, the number of mature pods and shelling percentage were similar among the varieties. The highest shelling percentage was recorded in Lanka Jumbo under 175 kg/ha gypsum application (T_4). The highest yield parameters were recorded in Lanka Jumbo variety, whereas, the lowest in ANK G1. There was no interaction effect among gypsum application and varieties in the yield parameters. From this study, it can be concluded that application of 175 kg/ha gypsum (T_4) to Lanka Jumbo variety (V_2) can be selected as suitable treatment combination to obtain the substantial yield from groundnut in Kilinochchi District in *Yala* season.

Keywords: Groundnut, Gypsum, Shelling percentage, Varieties, Yield parameters

Effect of Different Levels of Nitrogen Fertilizer on Growth and Yield Performance of Different Varieties of Groundnut (*Arachis hypogea* L.)

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Efficient utilization of applied fertilizer is essential to reduce the cost of fertilizer as well as environmental pollution. An experiment was conducted to assess the effect of different levels of nitrogen fertilizer on growth and yield performance of selected varieties of groundnut (*Arachis hypogea* L.) during the period of January to May 2020. Two factor factorial experiment was conducted in split plot design with three replicates. Nine levels of nitrogen fertilizer application; basal and topdressing N level 0% (control treatment (T_1), basal N level 0% and topdressing N level 50% (T_2), basal N level 0 % topdressing N level 100% (T_3), basal N level 50% and topdressing N level 0% (T_4), basal N level 50% and topdressing N level 50% (T_5), basal N level 50 % and topdressing N level 100 % (T_6), basal N level 100% and topdressing N level 0% (T_7), basal N level 100 % and topdressing N level 50% (T_8) and basal N level 100 % and topdressing N level 100% (T_9) were taken as the first factor and three groundnut varieties Tissa (V_1), Indi (V_2) and KCGN 1 (V_3) were used as the second factor. Groundnut varieties were planted at the spacing of 45 cm × 15 cm and all the other agronomic practices were carried out according to the recommendations of the Department of Agriculture except for fertilizer application. The soil properties, growth and yield parameters were recorded and shelling percentage was calculated. To find the significant differences among treatment combinations, ANOVA was performed by using SAS 9.1 package. The means were separated by using Duncan's Multiple Range Test (DMRT) at p= 0.05 to find out the best treatment combination. Plant height (cm) and yield parameters such as fresh weight of pods per plant, dry weight of pods per plant, matured pods number per plant, immature pods number per plant, 100 pods and seed weight, shelling percentage were recorded highest in treatment T_9 and non-significant difference was found between T_6 with T_9 treatment in Tissa variety. There was no interaction effect found among different levels of nitrogen fertilizer and varieties. Accordingly, it can be concluded that basal N level 50% and topdressing N level 100% (T_6) treatment and variety Tissa can be selected as a suitable treatment combination (T_6V_1) to achieve higher yields from groundnut for efficient utilization of nitrogen fertilizer while reducing cost.

Keywords: Groundnut, Nitrogen Level, Shelling percentage, Yield

Isolation and Identification of Efficient Phosphate Solubilizing Bacteria from Soil and Its Effect on Growth and Yield of *Zea mays*

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Phosphorus is an essential element for plant growth and development. However, phosphorous is highly insoluble and unavailable to the plant uptake when phosphate anions react with $Ca^{2+,}$ Mg^{2+}, Fe^{3+} and Al^{3+}. Phosphate solubilizing microbes can solubilize unavailable forms of phosphorous and make them available to the plants. The present study aimed at identifying the phosphate solubilizing bacteria and evaluates their performance in *Zea mays* plants. Bacteria were isolated from rhizosphere soil of *Zea mays* variety *Bhadra* and screened for P solubilizers on Pikovaskaya's (PVK) agar plates using phosphate solubilizing index. Molecular identification of the isolates were performed using 16S rRNA gene sequencing. A pot experiment with CRD design and three replicates was conducted with the following treatments; T1- soil, T2- soil + compost, T3- soil + compost + microbes, T4- soil + compost + biochar, T5- soil+ compost+ biochar + microbes, T6– soil + ERP (Eppawala Rock Phosphate), T7- soil + ERP + compost, T8- soil + ERP +compost+ microbes, T9- soil + ERP + biochar, and T10- soil + ERP + biochar + microbes. Growth and yield parameters of maize plants were measured. Data were analyzed by SAS statistical package and mean separations was done by Duncan's multiple range test at 5% significant level. Out of 13 strains isolated, PSM I had highest phosphate solubilizing index (2.43) and was selected for pot experiment. The strain was identified as *Streptomyces naganishii* by 16S rRNA gene sequencing. Application of soil + compost + biochar + ERP + microbe treatment resulted the highest growth and yield data. Yield per plant was higher in *S. naganishii* inoculated treatments namely T3, T5, T8 and T10 compared to their non-inoculated treatments (T2, T4, T7 and T9). Higher 100 seeds weight was shown by T3 (31.4 g), T5 (30.8 g), T8 (32.0 g) and T10 (33.1 g) than non- inoculated treatments. In conclusion the identified phosphate solubilizing bacteria *S. naganishii* can be utilized successfully to increase the growth and yield of *Zea mays*.

Keywords: Phosphate solubilization, *Streptomyces naganishii,* Rhizosphere, *Zea mays*

Application of Cattle and Poultry Manures in Combination with Foliar Application of Vermiwash on Growth and Yield of Okra

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As a cost-effective and ecological sustainable process vermitechnology has a great future in the field of organic waste management. Vermiwash, leachate produced during the process of vermicomposting contains macro and micronutrients along with microbes. In this regard, a pot experiment was conducted at the Crop Farm, Eastern University, Sri Lanka from January to April 2019 to investigate the influence of application of cattle and poultry manures in combination with foliar application of vermiwash on growth and yield of okra cv. P-11. The experiment was comprised of nine treatments and laid out in a Completely Randomized Design (CRD) with eight replicates. The treatments were; T1 = Control (recommended fertilizer), T2 = poultry manure 10 t/ha with 25% vermiwash, T3 = poultry manure 10 t/ha with 50% vermiwash, T4 = poultry manure 10 t/ha with 75% vermiwash, T5 = poultry manure 10 t/ha with 100% vermiwash, T6 = cattle manure 10 t/ha with 25% vermiwash, T7 = cattle manure 10 t/ha with 50% vermiwash, T8 = cattle manure 10 t/ha with 75% vermiwash, T9 = cattle manure 10 t/ha with 100% vermiwash. The growth and yield parameters including plant height, number of leaves/plant, dry weight of leaves, stems, roots, pods and total dry weight per plant were measured. The results showed that the foliar application of 100% vermiwash with 10 t/ha poultry manure increased plant height (30%), the number of leaves/plant (37%), dry weight of leaves/plant (52%), dry weight of stem/plant (38%), dry weight of root/plant (36%), dry weight of pods/plant (32%) and total dry weight/plant (43%), than that of recommended fertilizer. Hence, the experiment suggests that the application of poultry manure 10 t/ha + 100% vermiwash could be a sustainable method for obtaining high growth and yield in okra.

Keywords: Growth, Okra, Poultry manure, Vermiwash, Yield

Spatial Variability of Soil Carbon and Its Relationship with Nutrient Availability in Paddy Soils of Trincomalee District, Sri Lanka

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Global warming is likely to be the most threatening environmental issue. Hence, the soil's contribution to reducing CO_2 concentration from the atmosphere through the process of soil carbon sequestration has gained considerable attention. Therefore, this study was carried out to quantifying Total Soil Carbon (TSC) stocks and mapping its spatial variability using spatial soil data in paddy cultivation areas of Trincomalee district which acquires sixth rank of rice production in Sri Lanka. The sampling locations were allocated using Conditional Latin Hypercube Sampling Design. Fifty two sampling locations were allocated at 0-15 cm soil depth representing different soil types. TSC content was estimated by using CHN elemental analyzer and soil carbon stocks (t/ha) were calculated. Digital map was designed using distribution of TSC in each respective soil types. Moreover, Total Nitrogen (TN) and soil nutrients including K^+, Ca^{2+} and Mg^{2+} were analyzed using standard protocols. Pearson's correlation analysis was performed to determine correlation between TSC and other soil nutrient content. The results showed, the mean TSC stock ranged between 35.64 and 48.79 t/ha and average carbon stock was 41.59±2.5 t/ha in top soil layer. The Alluvial soil (48.79±3.32 t/ha) and Reddish Brown Earth & Low Humic Gley soil (45.95 ±3.27 t/ha) had higher carbon contents, than other soil types. The findings of this study highlighted the close relationship between soil type and the soil carbon distribution in paddy soils. Total carbon was positively correlated with TN, Ca^{2+} and Mg^{2+} and it showed linear relationship between soil carbon and other nutrients. Hence, this relationship depicts the importance of soil carbon towards plant nutrition. The information generated from this study will be useful for future carbon trading.

Keywords: Carbon sequestration, Mapping, Paddy soils, Soil carbon

Water Management, Farm Mechanization and Waste Management

Design, Fabrication and Testing of Four-Wheel Tractor Mounted Upland Channel Maker

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Irrigation is one of the very important practice in agriculture. There are many types of irrigation. Drip and Sprinkler are highly profitable irrigation systems with higher water application efficiency and less operational cost compared to traditional systems. However, most small-scale farmers cannot afford to install them due to high initial and maintenance cost compared to traditional systems. Currently, there are two lift irrigation systems in operation from two tanks such as Iranamadu tank and Muththaiyankaddu tank. Therefore, farmers of these areas are now adopting flood or basin irrigation systems. This irrigation system installation and operations are time-consuming and these activities are not mechanized yet. Therefore, the objective of this study was to mechanize the channel forming practice with a suitable channel former, as four wheel tractor attachment in order to reduce the cost and time. Newly fabricated channel maker was tested in different primary and secondary pre-ploughed lands with various gear ratios of the tractor and compared with the manual channel making. The results revealed that the newly fabricated channel maker performs well on the field prepared with disc plough and the rotavator plough with 1st and load gear ratios. It has been proven that the newly fabricated channel maker is more economical compared to the manual channel making as it can complete channel making job of 1-acre field within 40 minutes with high quality.

Keywords: Four-wheel tractor mounted upland channel maker, Gear ratios, Irrigation system

Households' Willingness to Pay for the Sewerage System in Jaffna Municipal Area, Sri Lanka

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Groundwater is the only source for drinking water in Jaffna municipal area. There is no sewerage system in this congested municipal area. Each household's toilet pits in this area have been constructed closer to their own drinking water source (wells). Due to the fecal contamination, ground water became unsuitable for drinking purpose. Therefore, there is an urgent need for piped sewerage system in Jaffna Municipal area. This study investigates the household's willingness to pay for the improved piped sewerage system in Jaffna Municipal area of Sri Lanka. For this study, 177 households were randomly selected from Jaffna Municipal Area and data were collected through interviews using structure questionnaire. Choice modeling was employed and conditional logit models were developed. The result of this study shows that, on average, a household residing in Jaffna Municipal area is willing to pay LKR 2582 per month for the piped sewerage system. Therefore, total willingness to pay for improved piped sewerage system per month by all households in Jaffna Municipal area is LKR 58.78 million. Household's preference order on the benefit attributes of sewerage system is as follows: increase in the space availability, reduction in maintenance cost, improvement in the environmental quality and reduction in the ground water contamination. Male household head is willing to pay less for the increase in space availability than female household head. Households living in less populated area are willing to pay less for the reduction in maintenance cost and improvement in environmental quality attributes than households living in densely populated area. Households with lower income are willing to pay more for the increase in space availability than the households with higher income. Households with less land extent are willing to pay more for the increase in space availability than the households with more land extent. This study suggests that there is a huge demand for improved piped sewerage system and households are willing to pay for the establishment of sewerage system. This study would assist various planners and authorities in formulating a suitable sewerage system and tariff for sewage services in the Jaffna Municipal area.

Keywords: choice Modeling, Sewerage system, Willingness to pay

Analysis of Residual Chlorine Concentration in Water Distribution System in Vavuniya District

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Per Aru reservoir is located in Vavuniya District and water from the reservoir is treated through the water treatment plant. Chlorine is used as a disinfectant and it should ensure that there is a constant minimum residual chlorine level (RCL) in all the parts of a distribution system. Further, the factors that influence chlorine decay should be identified. On this basis, the study was aimed to analyze the RCL concentration along the distribution system and find the locations with lower RCL concentration than the acceptable range (0.2 - 0.5 mg/L) and possible reasons for lower concentrations. A field study was conducted at the water distribution system connected to the Marakkarampalai overhead tank by collecting water samples at different locations. Totally 31 locations in the distribution system were selected. Water samples were analyzed for RCL concentration, pH, dissolved oxygen (DO) and temperature at the site itself. Collected data on RCL were statistically analyzed with one sample *t*-test, paired *t*-test and Duncan multiple range test. Information on the water distribution system; age of the pipe, pipe materials and diameter and distance from the overhead tank was collected. Results revealed that there was no significant difference in RCL concentration measured in different time periods however a significant difference was observed among the data collection points on the same day. The RCL concentration among the Marakkarampalai distribution system varied from 0 mg/L to 1.01 mg/L. Pattanichurpuliyankulam and Thirunavatkulam areas showed very low RCL concentration. Temperature of the collected water sample varies from 27.4 °C to 33.8 °C. Temperature range from 31 °C to 32 °C shows the acceptable RCL concentration. Higher temperature causes high RCL decaying which results in low RCL in consuming water. The pH and DO do not influence on RCL in consuming water. There was no any clear relationship recorded for pH and DO against RCL. Pipe age, Pipe material and Pipe diameter have no influence on residual chlorine decaying in this distribution system. Further, nearby areas to overhead tank shows sufficient amount of RCL in consuming water. However, the areas which are far away from the overhead tank and complex designed areas show lower amount of RCL in consuming water. Hence, actions need to be taken to ensure drinking water supply with acceptable range of chlorine in this water distribution system.

Keywords: Disinfection, Drinking water treatment, Residual chlorine

Design, Fabrication and Performance Evaluation of Millets (*Eleusine coracana*) Cleaning Machine for Domestic Level

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Finger millet is one of the most important food in human diet in the past as same as at present; because it contains large amount of nutrients. At the same time finger millet has a high demand in the society because most of diabetic patients are recommended to include finger millet in their diets. At present cleaning of finger millet is done manually, but it is rather difficult because it takes more time to separate impurities from the threshed finger millet. Many types of processing equipment have been developed and these machines are expensive and require more electricity to operate. However there is no machine has been developed to separate impurities from the threshed finger millet in domestic level. As a solution for this, a finger millet cleaning machine was designed, fabricated and evaluated at the National Institute of Post-harvest Management, Anuradhapura. The evaluation of the machine performance was done based on the following parameters: separation efficiency, separation loss, cleaning efficiency, cleaning loss at different feed rate, sieve slope and motor speed. Three level of sieve slopes (0^0, 3^0, 5^0), three level of motor speeds (250, 500, 750 rpm) three level of feed rates (125, 250, 500 g/min) were used. The experimental design was three factor factorial with CRD. The minimum losses and maximum efficiencies were achieved at 5^0 sieve slope, 500 rpm and 250 g/min feed rate. At that level the machine capacity was 15 kg/h, separation efficiency 95.23%, and cleaning efficiency 99.5%. Cost for the machine was Rs 10,000.00. Therefore this machine can be introduced as lower cost and easy to operate finger millet cleaning machine for domestic use.

Keywords: Cleaning machine, Design, Efficiency, Fabrication, Finger millet

Analysis of Rainfall Pattern over the Iranaimadu Tank during the Last Three Decades

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Iranaimadu tank is one of the major irrigation tanks in Northern Province of Sri Lanka. Water from this tank is used to irrigate agricultural lands in the Northern Province. Predictions on rainfall patterns are useful in planning the irrigation projects. The main objectives of the study are to examine the monthly and seasonal variation of rainfall and the rainfall trends over the Iranaimadu tank. This study was conducted using the monthly rainfall data of the past thirty years (1984 – 2018), which were collected from the Iranaimadu tank weather station. The analysis was carried out using monthly and seasonal mean rainfall data. The past three decades were divided as 1984-1994, 1995-2004 and 2010-2018 for the analysis. Magnitudes of the rainfall trends were derived by using linear regression analysis. The study reveals that the highest monthly rainfall was recorded in November. Further, March, June and July recorded less than 50 mm of mean monthly rainfall. Highest seasonal rainfall (553.8 mm) was recorded in Second Inter-Monsoon (SIM) and this was 40.51% of the total annual rainfall. Further, least seasonal rainfall of 106.2 mm (7.8%) was recorded during the First Inter-Monsoon (FIM) and it was 7.76% of the total annual rainfall. An increasing trend in the average monthly rainfall over the past three decades clearly found through the linear trend analysis, R^2 value is 0.9385 in December, which is statistically significant. Further, decreasing trend in the average monthly rainfall clearly shown in the linear trend analysis, where, R^2 value is 0.9984 in January. FIM and North East-Monsoon showed an increasing trend in the seasonal rainfalls with the R^2 values of the FIM was 0.4910 and 0.4654, respectively. Further, South West-Monsoon and SIM also showed a slightly increasing trend even though the changes were not statistically significant. In addition, average annual rainfall also showed a slightly increasing trend during the last three decades but not statistically significant.

Keywords: Iranaimadu tank, Rainfall trends, Regression analysis, Seasonal rainfall

Suitability of Groundwater for Drinking in Valukkai Aru Drainage Basin

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The surface stream, Valukkai Aru, in Jaffna Peninsula, Sri Lanka is only active during the monsoon and there are no reservoirs of a perennial nature. There are complaints by farmers regarding salinity problem in this area in the recent past. Freshwater availability is limited in the Valukkai Aru drainage basin area. Hence the study was aimed to assess the suitability of groundwater for drinking purpose. Initially, 114 wells were selected and groundwater samples were tested only for pH and EC. Based on EC, pH, land use and well type, 40 wells were chosen and groundwater samples were collected during the driest period, June 2020. Groundwater sample was analyzed by the standard methods for pH, electrical conductivity, total alkalinity, total hardness and chloride. Measured data were used to assess the suitability of groundwater for drinking purpose by comparing with the Sri Lanka Standard (SLS). Out of selected 114 well, only 8% of the selected wells were suitable for drinking purpose since the electrical conductivity of the groundwater was below the SLS desirable level of 750 µS/cm. Around 33% of the wells were not suitable for drinking or irrigation purpose since EC values were above the 3500 µS/cm. But most of the sample pH was within the range of 6.5 to 8.5. Total Hardness values were ranged between 232 - 3921 mg/L and 95% of the samples exceeded the SLS values for drinking water (250 mg/L) due to the dissolution of limestone and the substantial contribution from the weathering of limestone. Total alkalinity varied from 88 to 657 mg/L and 75% of the wells were above the recommended SLS desirable level of 200 mg/L. The concentration of chloride was between 47 and 8830 mg/L and 75 % of the samples exceeded the SLS desirable value for drinking water. High chloride concentration indicates the intrusion of seawater. The results reveals that the groundwater is not entirely fit for drinking with respect to EC, total hardness, total alkalinity and chloride.

Keywords: Electrical conductivity, Groundwater, Hardness, Quality, Valukkai Aru

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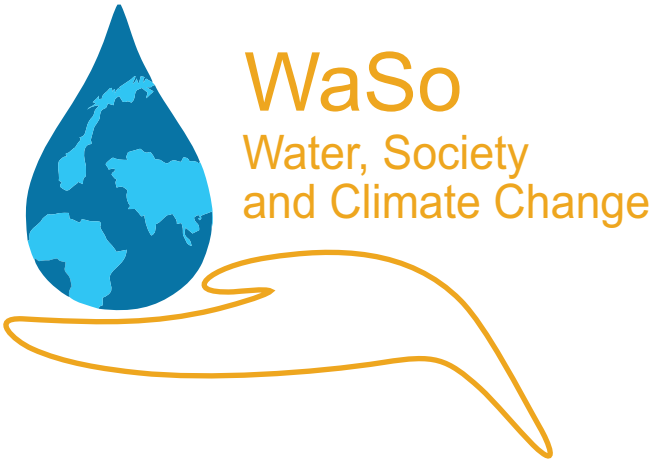

ISSN 2465-6143