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UNIVERSITY OF JAFFNA
SRI LANKA

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Editors

Dr.(Mrs.) S.Sivachandiran

Mrs.L.Pradheeban

Mr.K.Jeyavanan

Mr.K.Venugoban

Cover page Design

Mr.K.Venugoban

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Message from the Vice Chancellor

It is with great contentment I write this message to the International Conference on Dry Zone Agriculture (ICDA) 2016 that has been organized by the Faculty of Agriculture, University of Jaffna.

Organizing International Research Conferences is significant to gather eminent local and international researchers in all disciplines related to Agriculture and to give them a platform to share their knowledge and findings with others. The theme of the Conference **"Climate Smart Agriculture (CSA)"** explains the significance of greener growth for the agricultural sector, elaborates a policy toolkit for green growth in agriculture, and discusses important considerations in addressing specific environmental challenges in agriculture. According to FAO (2015), CSA aims to tackle three main objectives such as sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change and reducing and/or removing greenhouse gas emissions, where ever possible. Ultimately it helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. This Conference also provides a unique opportunity for agricultural experts, users and other researchers to meet, discuss the status of the research in climate smart agriculture and focus both on future needs and on the requirements to meet those needs.

I have no doubt that ICDA will be recognized as most prestigious and fruitful events organized by the Faculty of Agriculture, University of Jaffna. I take this opportunity to congratulate the Dean and the staff especially the organizing team of the ICDA-2016 for their dedication and untiring effort in making this event happen and to make it a great success.

I wish the deliberations of ICDA-2016 a great success

Snr. Prof. (Ms.) Vasanthy Arasaratnam,
Senior Professor of Biochemistry and the Vice Chancellor,
University of Jaffna,
Sri Lanka
December 2016

Message from the Conference Chair

I have the privilege to write this message to International Conference on Dry Zone Agriculture 2016 and welcome all guests, delegates and participants to Faculty of Agriculture, University of Jaffna. The theme of this year is '*Climate Smart Agriculture*', which is aptly designated to fit into today's need. Climate smart agriculture is a way to achieve short and long term agricultural development priorities in the face of climate change and serves as a bridge to other development priorities. With the vision of promoting innovative research for tomorrow's development with environmental concern, this conference is organized giving platform for the researchers to document and disseminate their findings. The conference also stimulates interaction and relationship among the students and scientists of different Universities and various Institutes locally and abroad.

The Faculty of Agriculture is one among the ten faculties of University of Jaffna and started in 1990. It has gone through many hard struggles in the past including displacements and long period of temporary residence. It is blessed now to get the support of the Ministry of Higher Education and University Grants Commission to reestablish at Kilinochchi in 2013 and celebrating 26th year of its successful existence. The Faculty is multiethnic and provides facilities for learning, research and dissemination. It is getting all the required facilities through the grants of Government of Sri Lanka, India and Japan. The Skill Development Center has a Conference hall, Library, Computer center and Indoor games are the gift from Government of India and Research complex and the Farm will be the gift of the Government of Japan through JICA grant. The support of both grants will empower the students and staff to excel in their skills in research and dissemination.

It is understood that the success of the conference depends ultimately on the people who are with us for planning and organizing both the technical program and supporting social arrangements. I am pleased to express my sincere thanks to our Guests, Keynote speakers, Authors of the research papers, Reviewers, Chairman of the sessions, Industries, Conference Convener and members of the organizing committee, Members of the editorial committee, Student Union, Students of the Faculty and many others who volunteered to

assist to make this very significant event a success. I am indebted to our sponsors for their valuable contribution to this conference.

Finally I wish the conference a great success and contribute immensely towards the development of the region and the Nation.

Prof. (Mrs.)Thushyanthy Mikunthan
Conference Chair/ ICDA 2016 & Dean/Agriculture

Message from the Convener

Faculty of Agriculture, University of Jaffna, Sri Lanka organized its 2nd International Conference on Dry Zone Agriculture (ICDA 2016) on 15th & 16th December 2016. It has been a real honor and privilege to serve as the Convener to the ICDA-2016.

Faculty of Agriculture was established in 1990 in Kilinochchi and displaced to Jaffna in 1997. After so much of hardship, Faculty was restablished in Kilinochchi in 2014 in its own buildings. The Faculty celebrated its Silver Jubilee in 2015 and organized an International Conference. Faculty Board of Faculty of Agriculture decided to conduct it as an annual event.

The theme of the ICDA 2016 is ***"Climate Smart Agriculture"***. The conference is organized for two days and includes 05 technical sessions, exhibition and social events which will provide ample opportunities for discussions and exchange of ideas and information among conference participants.

I am sure that the Conference will provide a unique platform for academia researchers and farming community for fruitful deliberations and exchange of ideas in the emerging areas of Agriculture and related fields. The galaxy of expert presence will enormously benefit young researchers attending the Conference from every corner of the country.

I take this opportunity to extend warm welcome to the resource persons and delegates registered for the Conference. I hope that the participant will have an enjoyable and fruitful stay at Ariviyal Nagar, Kilinochchi.

Dr.(Mrs.) S.Sivachandiran,
Converner ICDA 2016

Message from Conference Secretaries

It has been a real honor and privilege to serve as the Joint Secretaries of this conference. We warmly welcome you on behalf of the organizing committee of the ICDA 2016 for the International Conference on Dry Zone Agriculture with the theme of ***"Climate Smart Agriculture".***

According to the FAO statement, agricultural production will need to be increased by at least 70 percent to meet demands by 2050 due to the population growth and food consumption patterns. In this respect, developing ***"Climate Smart Agriculture"*** (CSA) is crucial to achieving future food security and climate change goals. This conference proceeding is bringing some of the key technical, institutional, policy and financial responses required to achieve the theme. The Conference programme is organized around five breakout sessions with sub themes of Agricultural Economics & Extension, Agroforestry & Natural Resource Management, Aquaculture & Fisheries, Biotechnology and Molecular Biology, Climate change, Environmental Management & Cleaner Agriculture, Nutrition, Food science & Technology, Plant Physiology, Plant Protection, Soil Science & Nutrient Management, Irrigation & Water Management.

We are greatly thankful to you to participate in this most enjoyable gathering of scientists belonging to the Universities and Industries from various sectors. We would like to thank the authors who expressed interests and submitted their papers to the conference. We thank to the Exhibitors who share the fruitful knowledge and experience on Agriculture production and their efforts have been the driving force of this Conference. We would like to express our sincere gratitude to the panel of reviewers, who provided timely reviews for the papers despite the tight schedule.

We wish to thank our Vice Chancellor Snr. Prof. (Ms.)Vasanthy Arasartnam and the Dean Prof. (Mrs.) Thushyanthy Mikunthan, Faculty of Agriculture, Heads of the Departments and Academic Staff, Faculty of Agriculture, for their tremendous support and guidance. We would like to say special thanks to Dr. (Mrs.) Sivamathy Sivachandiran,

the Convener of the ICDA 2016 for her invaluable guidance, support and teamwork to make this event successful one. We also would like to thank our special guests, key note speakers, chairpersons, presenters and participants for their valuable time and support. At this moment, it is necessary to extend our special thanks to the all staff, Faculty of Agriculture and the organizing team of the ICDA-2016. Last but not least, we are sincerely appreciate all who have supported us and contributed to this event in one way or the other, this event wouldn't have been possible without them.

We hope this conference will provide a fruitful environment to foster crucially important partnerships and collaboration.

Mr.K.Jeyavanan
Mr. K.Venugoban
Joint Secretaries-ICDA 2016

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Plenary Address I

Monitoring of the Land Surface and Simulation of the Water Cycling aiming for Sustainable Water Utilization

Shimada, S.

Laboratory of Regional Environmental Information Studies,
Department of Bio Production and Environment Engineering
Faculty of Regional Environment Science, Tokyo University of Agriculture, Japan.
shima123@nodai.ac.jp

Abstract

According to UNEP (1997), arid lands (including semi-arid area) accounts for 38% of the total terrestrial area. In these regions, evapotranspiration exceeds precipitation, which is less than 500 mm. Arid Land Greening Team in Tokyo University of Agriculture has been working, for 25 years, on greening projects in Djibouti, North-eastern African arid land where the annual rainfall between 100-170 mm. In the present presentation, our recent research topic on monitoring of the land surface and simulation of the water cycling are introduced. Aiming for sustainable water utilization, groundwater storage potential and greening potential are tried to be evaluated and delineated. Through those arid land study works, progress may be anticipated on some of the UN sustainable development goals, i.e. achieving food security and promoting sustainable agriculture with ensuring availability and sustainable management of water.

Water Cycling Simulation

With recent advancements in computer technology and numerical methods, researchers have been able to develop physical based models to simulate runoff and groundwater flow on watershed scale. The present address introduces the recently developed watershed modeling tool for simulation to estimate the water flow in both surface (Manning's flow) and subsurface sections (Generalized Darcy's flow) of a basin watershed, the fluids flow code GETFLOWS (Tosaka et al., 2000) (Fig. 1). A 3D flow model of a watershed was developed in order to simulate the watershed runoff and the groundwater flow. In this work, a 3D groundwater flow model constructed with GETFLOWS

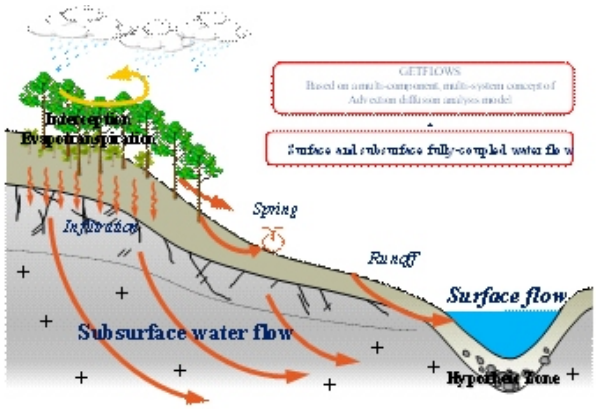

Fig. 1 Conceptual model of GETFLOWS simulator.

integrating all important geological features of the hydrogeological system is developed to investigate hydrological processes in the Wadi (ephemeral stream) Ambouli watershed of Djibouti. The existing data set for model calibration is scarce, which is a typical situation for many hydrogeological case studies. At first, the steady state of the groundwater model is carried out based on the observation wells and by applying the time and space-dependent recharge from precipitation at the top surface of the model. The preliminary results show that the calculated water levels are close to the actual observed values (Malow et al., 2016). Since the Wadi Ambouli watershed is the important catchment area providing with freshwater the capital city of Djibouti, the model developed in this study can be regarded as a useful tool for analyzing the hydrological processes and improving groundwater management practices of the catchment and elsewhere in the country affected by similar geological and hydrogeological conditions.

In the present address, I would also like to introduce the water flow estimation case study which has been done in Sri Lanka using GETFLOWS (Tawara, Perera et al., 2011). In this case study, data are used from the various available resources, vis. Weatherbase rainfall and temperature data (www.weatherbase.com), ISCGM (international Steering Committee for Global Mapping) land use data (http://www.iscgm.org/), NASA Shuttle Radar Topography Mission (SRTM) dataset with GTOPO30 data, Geological map of Ceylon, Soil map of Sri Lanka, and Soils and Agro-Ecological environments of Sri Lanka (Panabokke, 1996). Output maps are surface water flow and river network, groundwater contours (Fig. 2), and distribution of groundwater springs, 3D stream lines and seawater-fresh water interaction.

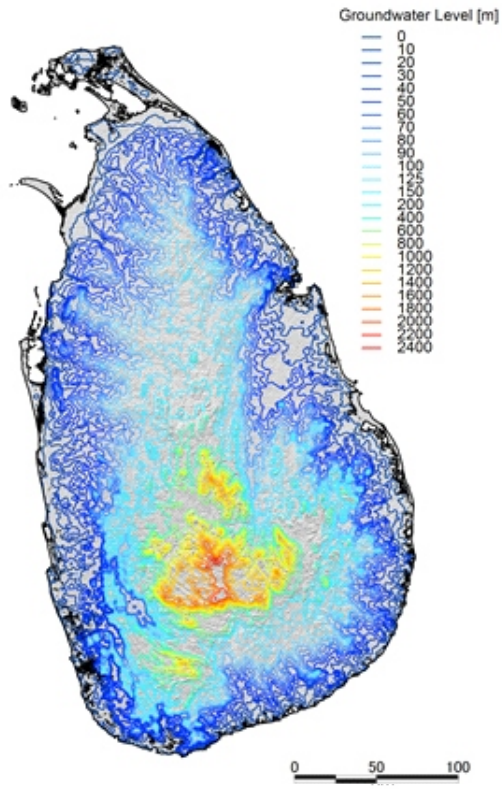

Fig. 2 One of the output maps form GETFLOWS simulation in Sri Lanka (Groundwater contour lines).

Land potential assessments have to be conducted for optimizing the farming locations. In the arid lands, potential on water resources are the critical parameter for plant growth. These kind of maps derived from the water flow simulation, hence, can be utilized as a greening

potential indicator in the undeveloped area in an arid land.

Aiming for Precision Farming

Water is one of the most precious resources in arid lands. Precision farming is the key to optimize the sustainable agricultural productiveness with preserving water and other input resources. The present address introduces our approach on the precise agricultural land monitoring aiming for precision farming. A cost-effective commercial drone (DJI Inspire1), which enables to acquire high spatio-temporal resolusion data, is used to monitor in this study. This drone loads an RGB sensor camera (Zenmuse X3, CMOS: Sony EXMOR 1/2.3). In order to capture near infrared wavelength region (750 1,000 nm), we replaced the RGB lens of the mounted camera (20 mmn f/2.8, FOV: 94□) into NDVI lens (4.35mm NDVI Filter, f/2.8, FOV: 72□, Peau Productions). Where, NDVI (Normalized Difference Vegetation Index) is the vegetation activity indicator calculated from the below equation (1).

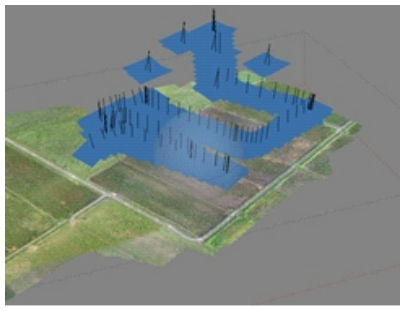

Fig. 3 Image of drone flight track with position and angle of each monitoring image on a farmland.

$$NDVI = \frac{NIR - RED}{NIR + RED} \qquad eq(1)$$

Where, *NIR* refers to the reflectance in near infrared, and *Red* in red wavelength (600 700 nm). The drone flight monitoring using this mounted modified camera (Fig. 3), enables us to draw ortho-rectified distribution map of crop NDVI (Fig. 4). This heterogeneous distribution of the crop activity tells you where to adopt measures (e.g. irrigation, fertilization). More detailed information on crop growing and quality status, e.g. indicators on crop water or salt stresses, chemical contents in crop leaves are also in the process of development.

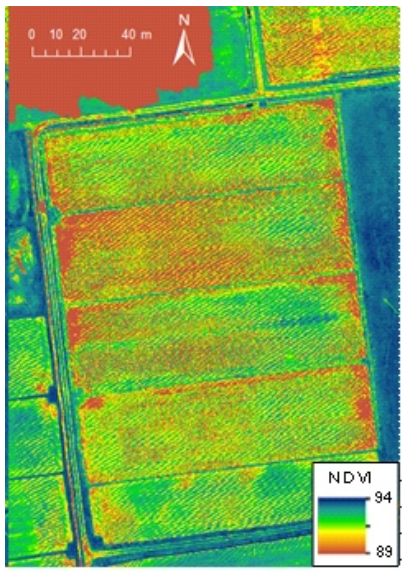

Fig. 4 Distribution map of cropland NDVI (rice paddy in Japan) derived from modified lens mounted drone images.

Precise monitoring would develop agricultural productivity both quantatively and qualitatively in dry region like North Sri Lanka with promoting sustainability by preserving resources.

Plenary Address II

Microbial Mediated Sulfur, Silica, Phosphorous and Nutrients to the Plants for Sustainable Agriculture in Dry Lands

Anandham, R.

Department of Agricultural Microbiology, Agricultural College and Research Institute, Madurai 625 104, Tamil Nadu Agricultural University, Tamil Nadu, India.

anandhamranga@gmail.com

Abstract

Sulfur (S) is increasingly being recognized as the fourth major plant nutrient after nitrogen, phosphorus and potassium. It is a constituent of amino acids cysteine and methionine, which act as a precursor for the synthesis of all other compounds containing reduced sulfur (Scherer, 2001). Sulfur is essential for both plant and animal life. Although the element is required by plants in amounts comparable to phosphorus, the first field case of sulfur deficiency was reported only in 1933. In wetland rice, sulfur deficiency was first reported in 1938. During the last 10 years, sulfur deficiency has been recognized as an important growth-limiting factor for both dry land crops and wetland rice. In Asia, sulfur deficiency of wetland rice has been reported in Bangladesh, Burma, India, Indonesia, Japan, Philippines and Sri Lanka. Responses to sulfur have been reported for 23 crops in 40 tropical countries. This occurrence of sulfur deficiencies has been accentuated by the increase in use of low sulfur fertilizers, decrease in use of organic manures, intensive cropping and reduced atmospheric deposition. To alleviate sulfur deficiency, sulfur fertilizers are invariably added to soils, usually in a reduced form, such as elemental sulfur. Use of S oxidizers enhances the rate of natural oxidation of S and speed up the production of sulfates,and makes them available to plants at their critical stages, consequently resulting in increased plant yield.

Forms of Sulfur

The distribution of organic S within a soil profile follows the pattern of organic matter and decreases with depth. Soil organic S can be divided into three fractions: C-bonded S, /non C- bonded S, and the soil biomass. The greater part of total organic S in soils of humid and semiarid regions are present as C- bonded S. Separation of this fraction is

difficult since these S- containing compounds undergo extensive transformations. Inorganic S occurs in soil largely as sulfate. S is available to plants as sulfate in the liquid phase of the soil. Under anaerobic conditions, S is present in reduced forms. A major fraction of the S in calcareous and saline soils occurs as gypsum ($CaSO_4 \cdot 2H_2O$). In arid regions, high amount salts such as $CaSO_4$, $MgSO_4$ and Na_2SO_4 can accumulate.

Crop Response to Sulfur

Legumes usually require almost equal amount of phosphorus and sulfur. When P and S are present below the critical level in soil, the plant growth and qualities of produce are affected adversely. Dhillion and Dev (1978) indicated that soybean is quite responsive to sulfur application and it has a high sulfur requirement due to higher quantities of protein and S containing amino acids (methionine, cysteine and cystine) thus vital for protein synthesis. Riley *et al.* (2000) reported that application of micronised sulfur increased wheat yield and sulfur uptake by 36 and 164%, respectively. Histuda *et al*. (2005) observed early plant growth promotion of rice, maize, field bean, wheat, cotton, sorghum and sunflower due to sulfur application.

Deficiency Symptoms

Sulfur, as a constituent of nitrate reductase is involved in the conversion of nitrate into organic nitrogen. Sulfur deficiency consequently interferes with nitrogen metabolism, which explains why sulfur deficiency resembles nitrogen deficiency in many crops. However, the symptoms usually are not dramatic and are not localized on the older leaves. Lack of sulfur appears as light green coloring of the whole plant.

Characterization of Sulfur Oxidizing Bacteria (SOB)

Beijerinck (1904) isolated thiosulfate oxidizing organisms (*Thiobacillus thioparus*) from fresh water canal mud and salt water. He also reported that *T. thioparus* produced a thick pellicle consisting of sulfur enclosing bacterial bodies. *T. thioparus* was isolated from soil, ditchwater, sewage and sea water and its oxidation of sulfur and sulfide has been studied by various authors. Waksman (1922) isolated an organism, which was able to oxidize sulfur very rapidly to sulfuric acid. It was a small color less, non-thread-forming organism using primarily elemental sulfur as a source of energy, not accumulating any

sulfur within or outside its cells. Starkey (1935) isolated sulfur-oxidizing bacteria from black clay loams. Sulfur oxidizing bacteria such as *Boseathio oxidans*, *Pseudaminobacter salicylatoxidans*, *Paracoccus bengalensis*, *Mesorhizobium thiogangeticum*, *Tetrathiobacter kashmirensis*, *Paracoccus pantotrophus* and *Paracoccus thiocyanatus* were isolated from rhizosphere and bulk soils of agricultural fields of India. Also, thiosulfate oxidizing *Xanthobacter tagetidis* and *Methylobacte riumthiocyanatum* were isolated from rhizosphere of marigold and Persian onion, respectively. Recently, Anandham *et al.* (2005; 2007; 2008a,b; 2009a,b; 2010) have isolated several obligate and facultative chemolithotrophic thiosulfate oxidizing bacteria in rhizosphere soils and documented their ubiquitous presence in rhizosphere of crop plants of Korea (Yim *et al.*, 2008).

Sulfur Oxidation in Soils

The soil incubation experiments were performed to assess the sulfur oxidation in Korean soils. The physico-chemical properties of the selected clay, silty clay, and sandy loam soils were as follows: sand 21.7, 2.2, 73.4%; silt 32.4, 46.60, 13.6%; clay 45.9, 51.20, 13.0%; pH 7.3, 6.0, 6.3; EC 327, 206, 133 dS m^{-1}; organic matter 3.4, 1.63, 1.8%; total nitrogen 0.24, 0.03, 0.09%, total phosphorous 132.2, 284.0, 295.7 mg kg^{-1}; total SO_4-S 18, 20, 12 µg g^{-1}, respectively. In the clay and sandy loam soils, inoculation of *Dyellagin sengisoli* accumulated the maximum sulfate-sulfur (1927 and 2527 µg SO_4-S g^{-1} soil, respectively) when compared to the other strains on day 30. Meanwhile, in the silty clay soil, *Microbacterium phyllosphaerae* registered the highest sulfate-sulfur content, followed by *D. ginsengisoli*.

Plant Growth Promotion by SOB

Combined application of *Thiobacillus*, elemental sulfur and phosphobacteria increased the yield in maize. Pathiratna *et al.* (1989) reported that pelleted apatite mixed with S and *Thiobacillus* increased the shoot dry matter and yield. In a pot culture study, inoculation of sulfur oxidizing bacteria significantly increased the root and shoots lengths, leaf width, pod dry weight of canola. Application of sulfur (300 Kg ha^{-1}) inoculated with *Thiobacillus* increased the dry matter production of *Leucena* and decreased the soil salinity, whereas increased concentration of sulfur (600 Kg ha^{-1}) produced negative results

(Stamford *et al*. 2002). Similarly, application of sulfur with co-inoculation of *Thiobacillus* with *Bradyrhizobium* significantly enhanced the yield of cowpea and yam bean (Stamford *et al.* 2003). In field trial *Thiobacillus* sp. applied at 60 kg ha^{1} significantly increased the groundnut nodule number and nodule dry weight by 32% and 43%, pod yield (2%) and oil content (3%) over pellets applied at 20 kg ha^{1} (Anandham *et al.* 2007). Similar results were also observed in pot experiment (Anandham *et al.* 2007). A significant effect on sugarcane stalk dry matter yield from phosphate and potash rocks was observed with the application of sulfur and *Acidithiobacillus* (Stamford *et al*. 2008), available P and K and exchangeable Ca and Mg increased with *Acidithiobacillus* application compared to mineral fertilizers and P and K rocks alone. Further, it was concluded that biofertilizers produced from phosphate or potassium rock mixed with sulfur inoculated with *Acidithiobacillus* may be used as an alternative to soluble fertilizers for the fertilization of sugarcane grown in soils with low available P and K (Stamford *et al.* 2008).

Silicon in Soil

Silicon is abundant in the earth's crust (constituents up to 28%) and occurs in various complex mineral forms. The main forms of silicon in soil are dissolved silica mainly monosilicic acid (H_4SiO_4) and polysilicic acid ($SiO_2.nH_2O$), crystalline and amorphous silica, Si $(OH)_4$ and Mn silicates.Silicon is also believed to be beneficial to rice plants by increasing available phosphorus in soil, enhancing uptake of phosphorus, improving water use efficiency, reducing toxicities associated with Mn, Fe and Al, increasing mechanical strength of stems, improving growth habit, reducing shattering of grains and controlling insect pests.

Identification of an efficient soil bacterium that might solubilize silicate could pave way for the release of other essential nutrients in soil. Yeo *et al*. (1999) found that Si reduced sodium uptake in rice in saline conditions by a reduction in the transpiration by pass flow. By compartmentation of Si and increases the binding of Mn to the cell wall or produce a more homogeneous distribution of Mn in the leaves.

Silicate Solubilizing Bacteria (SSB)

Norkina and Pumpyanskaya(1956) reported that the silicate solubilizing bacterium *Bacillus musiliaginosus* var. *siliceous* liberated potassium from feldspar and alumino

silicates *in vitro* conditions. The ubiquitous occurrence of silicate solubilizing bacteria in rice rhizosphere has been encountered previously. Potassium-solubilizing bacteria are normally silicate solubilizing bacteria, capable of degrading silicate minerals and releasing potassium and other elements in the available forms for plant use. The maximum silicate solubilizing bacteria was found in rhizosphere soils of system of rice intensification (SRI) (8.51×10^3 cfu g^{-1} of dry soil) and aerobic rice (8.26×10^3cfu g^{-1} of dry soil) on 15 and 45 days after transplanting, respectively (Karthik, 2012).

Possible Mechanisms of Silicate Solubilization

The growth of certain bacteria in media containing silicates was well established. The process of autoclaving for sterilization itself has released some amount of silica from these minerals suggesting the role of higher temperature of autoclaving, similar to weathering, as reported by Hall (1972).The solubilization of silica from silicate minerals might be due to several metabolites viz., i) Carbon di-oxide ii) Organic acids iii) Alkalines iv) H_2S and v) Exopolysaccharide synthesized by bacteria.

It is well known that CO_2 is a product of microbial decomposition of organic matter and root respiration. Walksman and Starkey (1924) showed that action of carbon-dioxide, a product of respiration or fermentation of organic amendments by any microorganism on orthoclase degradation.

$$2\ KAlSi_3O_8 + 2\ H_2O + CO_2 \rightarrow H_2Al_2Si_2O_9 + K_2CO_3 + 4\ SiO_2$$

Orthoclase Kaolinite

Duff and Webley(1959) reported the dissolution of silicates due to complexing of 2-keto-gluconate with cationic components, as these complexes are more stable than silicates.

$$Ca\ SiO_3 \rightleftharpoons Ca^{++} + SiO_3^-$$

$$Ca^{++} + 2\ \text{Keto-gluconate} \rightleftharpoons Ca\ (2\text{-Keto-gluconate})$$

Organic acids are inherent in biological materials and microorganisms synthesize them during their cellular metabolism and also excrete on the substrates in which they obtain foot hold. These organic acids elaborated or excreted play a role in weathering and such mechanism might also operate in the *in vitro* breakdown as well as in the soil.

Effect of Inoculation of SSB in Crop Plants

Strain *Bacillus edaphicus* NBT was able to mobilize potassium efficiently in both plants when illite was added to the soil. In cotton and rape grown in soils treated with insoluble potassium and inoculated with strain *Bacillus edaphicus* NBT, the potassium content was increased by 30 and 26%, respectively. Bacterial inoculation also resulted in higher N and P contents of above ground plant components. The bacterial isolate was also able to colonize and develop in the rhizosphere soil of cotton and rape after root inoculation. Application of silicate solubilizing bacterial strain *Pseudomonas gessardii* SSB7 and *Achromobacter xylosoxidans* SSB2 recorded the maximum seed germination (88 and 91 %), plant height (85.6 and 55.1 cm) and biomass (3.10 and 3.60 g plant^{-1}) in rice cv., ADT 39 and Anna (R) 4, respectively in wet land and aerobic condition (Karthik, 2012).

Zinc Solubilization

A term called zinc solubilizing bacteria (ZSB) was coined for those bacteria that are capable of solubilizing the insoluble zinc compounds / minerals in agar plate as well as in soil (Saravanan *et al.*, 2007). Zinc is an essential micronutrient that plays a vital role in various metabolic processes in plants, and its deficiency adversely affects the growth and development of crop plants. The available zinc content in Indian soils is low; however, the total zinc content is substantially high and exists in fixed forms such as smithsonite ($ZnCO_3$), sphalerite (ZnS), zincite (ZnO), franklinite ($ZnFe_2O_4$), wellemite (Zn_2SiO_4), and hopeite ($Zn_3(PO_4)_2 \cdot 4H_2O$), which are sparingly soluble. It is plausible that exploitation of zinc solubilizing bacteria may aid in overcoming zinc deficiency.

Senthilkumar (1997) isolated zinc solubilizing organisms from rice rhizosphere and ore sources and the studies on inoculation of zinc solubilizing bacteria in rice under plot

culture resulted in correction of zinc deficiency in addition to increased growth parameters. Zinc solubilizing microorganisms can solubilize zinc from inorganic and organic pools of total soil zinc and can be utilized to increase zinc availability to plants. However, only some bacterial species of the genera *Acinetobacter*, *Bacillus*, *Gluconacetobacter* and *Pseudomonas* have been reported to solubilize zinc. Inclusion of a bacteria solubilizing zinc, as a bioinoculant in crop production technology is really beneficial for a country like India having high incidence of zinc deficiency more than 70%. Iqbal *et al.* (2010) examined the application of zinc solubilizing bacterial isolates along with zinc phosphate increased plant growth parameters, seedling length in *Vignaradiata*.

Conclusion

Drought, one of the major abiotic stresses, has been weighing heavily against the agricultural productivity worldwide since most of crops and forage plants grown to feed the global population are highly sensitive to drought. This stress also induces severe desertification, with a progressive reduction of the vegetation cover coupled with rapid soil erosion in arid and semi-arid climatic region. Drought affects water potential and turgor in plants, resulting in the changes of physiological and morphological traits. Among the various impacts of drought on plant growth, nutrient availability and restricted water are the two main ones commonly discussed. Plant growth promoting bacteria (PGPRs) are microorganisms associated with plant roots and can confer beneficial effects on the host plant and offer sustainable farming in dry lands.

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Keynote Address I

Spatial Estimation of Evapotranspiration Using Satellite Imagery From Regional to Global Scales

Tasumi, M.
Fuculty of Agriculture, University of Miyazaki, Japan.
tasumi@cc.miyazaki-u.ac.jp

Introduction

Global population increase has resulted in an urgent need to improve the management of natural resources, such as land, water, and energy. Sustainable use of limited resources is important in the agricultural sector, as agriculture is a primary user of land and water. In the world, 69% of fresh water is used for agriculture, 21% is used for industry, and 10% is used for domestic purposes (Clarke and King, 2004). Understanding evapotranspiration (*ET*) from land is valuable, especially in agriculture. Reference (or potential) *ET* determines crop and irrigation water demands, and it is basic information of water resource planning. Actual *ET*, which is controlled by weather, soil, and surface conditions, is strongly related to crop growth and yield. At the basin scale or larger scale, such as that of a large irrigation district, *ET* is important information for the planning and management of water resources because it represents the consumptive use of water.

Satellite remote sensing is a powerful tool for the estimation of actual *ET* and both its spatial and temporal variations. According to Biggs et al. (2016), satellite-based *ET* estimation methods can be categorized into three groups: (1) vegetation-based models including the method proposed by Nagler et al. (2009) and the MODIS MOD16 *ET* estimation algorithm (Mu et al., 2011), (2) radiometric land surface temperature-based models such as SEBAL (Bastiaanssen et al., 1998), METRIC (Allen et al., 2007a,b), ALEXI (Anderson et al., 1997), and SSEB (Senay et al., 2007), and (3) scatter plot or triangle methods including the methods proposed by Moran et al. (1994), Roerink et al. (2000), and Nishida et al. (2003). The ideal location for applying such techniques might be areas of irrigated agriculture in arid and semiarid regions, because the low probability of

cloudy days allows frequent observation of the land surface by satellite and agricultural water is precious in these regions. Recent progress also allows the application of this technique to humid regions, such as by using satellite images with higher temporal resolutions.

Evapotranspiration estimation models

This paper presents the development and applications of two *ET* estimation models: (1) the METRIC *ET* estimation model (Allen et al., 2007a,b) for regional applications and the (2) GCOM-C global ET_{index} algorithm (Tasumi et al., 2016a,b) for global application. Both models rely largely on satellite observation of surface temperature. The METRIC model conducts a complete energy balance for each satellite pixel using satellite shortwave and surface temperature observations, with the help of ground-measured weather data. In the model, latent heat flux (λE), which is readily convertible to ET, is estimated by an energy balance equation:

$$\lambda E = R_n - G - H, \quad (1)$$

where R_n is the net radiation computed by solving the surface radiation balance, G is the soil heat flux, and H is the sensible heat flux. R_n, G, and H are estimated using satellite shortwave and surface temperature observation data, along with ground-measured weather data, by employing theoretical and empirical equations.

The GCOM-C model employs a simple conversion of satellite-observed surface temperature to ET information by using a global weather dataset:

$$ET = C_{adj} \times \frac{T_s(\text{dry}) - T_s(\text{act})}{T_s(\text{dry}) - T_s(\text{wet})} \times ET_o, \quad (2)$$

where C_{adj} is an adjustment factor, T_s(act) is the instantaneous actual surface temperature from satellite thermal observation, T_s(wet) and T_s(dry) are the wet surface temperature and the dry surface temperature, respectively, determined primarily by the time and location information with some help from weather data, and ET_o is the reference evapotranspiration defined by Allen et al. (1998), which is calculated using a global or ground-measured weather dataset.

Application Examples

The METRIC model has been applied widely to achieve sustainable use of agricultural water. Fig. 1 shows an application example of the METRIC model for an irrigation district in southern Spain, which was reported by Santos et al. (2008). The derived *ET* map, as shown in Fig. 1, provides *ET* with spatiotemporal variations, which is useful for the planning and management of agricultural water, such as for analyzing irrigation performance, for monitoring water-rights, and for calibrating a regional aquifer model. Fig. 2 shows an application example of the GCOM-C global *ET* algorithm, applied using MODIS surface temperature images for the year 2001, reported by Tasumi et al. (2016b). The results are applicable to understanding the overall *ET* circumstances in the globe, the yearly trend of aridity, and the impact of climate change, and also as a tool for initial investigations of regional agricultural water resources management. In addition, applying this model to satellites having finer spatial resolution, such as Landsat, can allow field-level estimation of *ET* in some countries where agricultural field sizes are relatively larger.

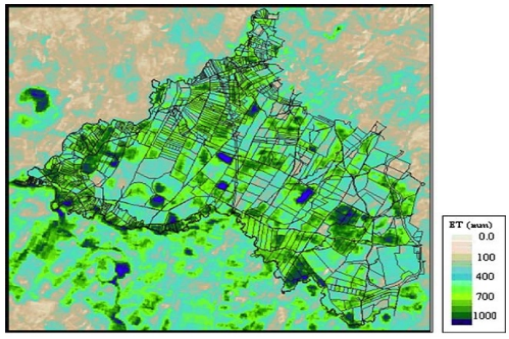

Fig. 1. Seasonal *ET* determined by the METRIC model for the Genil-Cabra irrigation scheme (Santos et al., 2008).

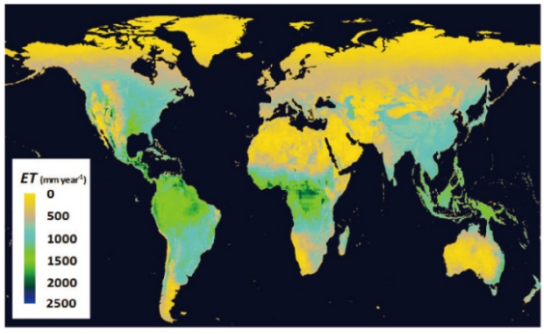

Fig. 2. Annual *ET* estimated by GCOM-C ET_{index} algorithm for the year 2001 (Tasumi et al., 2016b).

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Keynote Address II

Environmental Stress Management through Mycorrhizal Symbiosis in Horticultural Plants

Matsubara, Y.
Laboratory of Horticultural Science,
Faculty of Applied Biological Sciences, Gifu University, Japan
ymatsu@gifu-u.ac.jp

Introduction

Arbuscular mycorrhizal fungi (AMF) are known as symbiotic fungi with the effect of promoting host plant growth mainly by enhancing phosphorus uptake through symbiosis. AMF is considered to develop a sustainable ecofriendly strategy to overcome biotic and abiotic stresses in plant production as well as safe agricultural production. As for environmental stress management of biotic and abiotic stresses via AMF, few reports have been demonstrated and the mechanisms still have many unclear points. In this lecture, the events on plant adaptation to biotic and abiotic stresses through AMF symbiosis and the mechanisms in mycorrhizal horticultural plants are introduced.

In asparagus producing regions, early decline and replant problem frequently occur in the fields. These phenomena are known as asparagus decline. Asparagus decline is supposed to be caused by the contribution of both abiotic (allelopathy etc.) and biotic (plant diseases) factors. In this study, PCR-SSCP (single-strand conformational polymorphism) method was established for analyzing biotic factor of asparagus decline in Japan. As the result, *Fusarium oxysporum* f. sp. *asparagi* and *Fusarium proliferatum* were dominant species which lead to asparagus decline. Then, biological control of Fusarium crown and root rot was attempted by AMF. Five cultivars of **Mycorrhizal Asparagus Plants** showed tolerance to Fusarium crown and root rot, and the increases in followed antioxidative ability, SOD (superoxide dismutase) with high intensity of **Cu-SODs isozyme**, APX (ascorbate peroxidase) activity, contents of polyphenol and ascorbic acids, DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging activity, were closely associated with the tolerance. Generally, if plants get environmental stresses, such as disease, high

temperature, drought, salinity, reactive oxygen species (ROS), such as superoxide anion radical (O_2^-) and hydorogen peroxicide (H_2O_2) were synthesized in cells. For such oxidative stress, plants resolute such ROS by enzymatic antioxidant of SOD, APX, CAT (catalase) and non-enzymatic antioxidants of polyphenol and ascorbic acid into harmless substances such as H_2O and O_2 and keep metabolism. As for the histological aspects of Fusarium root rot tolerance, short cells in asparagus root dimorphic exodermis regulated AMF and Fusarium entry as passage cells with suberin-less, resulting in the disease tolerance. In addition, **s**ymbiosis-specific increase in free amino acids, such as arginine and GABA (gamma-amino butyric acid), suppressed Fusarium propagation in vitro. On the other hand, in the practical asparagus decline fields, mycorrihizal asparagus plants showed disease tolerance and increase in yield and antioxidants in asparagus ferns, though the effect differed with fungal species.

In strawberry and cyclamen (ornamental plant) cultivations, *Fusarium wilt and anthracnose are the important diseases which are difficult to control.* Mycorrhizal strawberry and cyclamen plants showed tolerance to Fusarium wilt and anthracnose and induced systemic resistance (ISR). In addition, the increases in followed antioxidative ability, SOD, APX activity, contents of polyphenol and ascorbic acids, DPPH radical scavenging activity, were closely associated with the tolerance. Similar relationships have been found in mycorrhizal asparagus. In addition, cross-protection against heat stress and disease in mycorrhizal cyclamen was recognized with proteomic analysis. AMF could alleviate heat stress with promoting host plant growth and induce resistance to anthracnose under heat stress. In addition, it supposed that antioxidative modification would have cross association with the resistance to heat stress and anthracnose, and the symbiosis-specific changes in some proteins would have concern with the cross protection; some might be concerned with HSP.

Japan got tsunami disaster in 2011. After that, in horticultural aspects, it is still difficult to re-start of vegetable cultivation, because removing salt from soil costs high and takes long time, and vegetables with high salinity tolerance are very limited and no one exist in major

crops. Generally, salinity (usually, experimented salt) stress to plants is caused by 2 major factors such as ion stress and osmotic pressure stress. Concerning ion stress, Na^+ toxicity and changes in mineral ion balance are concerned, and as for osmotic pressure stress, high osmotic pressure caused restriction in water and nutrient uptake. These factors induce oxidative stress and increase ROS, and resulted in salinity injury in plants. Alleviation of ion stress by antioxidative ability, and amelioration of osmotic pressure by accumulating compatible solute (such as free sugar, free amino acids etc.) in cells are important for increasing salinity tolerance in plants. In this study, salt tolerance in mycorrhizal vegetable plants and physiological changes through symbiosis were investigated. Salinity tolerance (200mM NaCl and sea water) occurred in mycorrhizal asparagus, tomato and strawberry plants with the increase in chlorophyll content and growth promotion. Na^+ concentration and Na^+/K^+ in shoots and roots were lower in AMF plots. From these findings, Suppression of Na^+ uptake and limitation of translocation of Na^+ from roots to shoots are supposed to be considered in mycorrhizal plants. As for Na^+ ion diversity in plant tissue, SEM-EDX analysis using nano-suit-treated horizontal section of strawberry petiole and main root with NaCl treatment was carried out. In control tissue, Na^+ accumulated close to vascular bundle, and in AMF plant tissue, Na^+ diversity resembles with control tissue, but the levels were lower compared to control. So that, Na^+ tissue diversity itself differed little between AMF and control, but the accumulation levels were totally lower in AMF, because of the suppression of Na^+ uptake in roots by apoplastic barriers as a possible cause. In addition, increase in antioxidative activity for the oxidative stress caused by ion stress of Na^+ was associated with the tolerance. In another physiological analysis, several free amino acids increased under salt stress condition in mycorrhizal plants. These increase are also considered as reducing ion stress and accumulating compatible solute which ameliorate osmotic pressure by salt stress.

From these findings, mycorrhizal horticultural plants are suggested to show biotic and abiotic stress tolerance; and physiological and histological factors brought about by the mycorrhization could be involved with the tolerance.

Youth Participation in the Informal Labour Market: The Case of the Northern Province of Sri Lanka

Balamurali, N.[1]* and Dunusinghe, P.[2]

[1] *Department of Social Studies, Open University of Sri Lanka,* [2]*Department of Economics, University of Colombo*

**balamurali_navaratnam@yahoo.com*

Informal economy (IE) plays a major role in employment creation, production and income generation while the formal sector of the country cannot absorb all the labour force of the country. More than 70 per cent of Sri Lanka's labour force is employed in the informal sector (Arunatilake, 2010). This study aimed at assessing the nature and characteristics of IE with reference to youth employment in the Northern Province of Sri Lanka. We extracted data from the Labour Force Survey (LFS) of four years from 2011 to 2014, conducted by the Department of Census Statistics of Sri Lanka. This study was started with the research problem with the notion that, Larger share of employed youth in the Northern Province engage in Informal Economy. Hence, the researcher wanted to identify 'the characteristics of youth who engage in the Informal Economy in the Northern Province'. According to this study, Contribution of IE in the Northern Province continuously declines during the last four years. In addition, the share of IE among female youth declines faster than males during the study period. However, IE still plays a significant role as 43.9 per cent of employed youth participate in the IE in the Northern Province where it is 35.2 per cent in the country in 2014. Except the Mannar district, all the other districts in the Northern Province show the decline in the share of IE during the period from 2011 to 2014. As the level of education increases, participation of youth in the informal sector decreases and this is opposite for formal sector. IE increases as age increases. Particularly it is relatively higher among the youth who are between 25 to 29 years old. Skilled agricultural and fishery workers; Craft and related workers; Plant and machine operators and assemblers; and Elementary occupations are the four dominant economic activities of the informal workers. This study found that although IE plays an important role in reducing unemployment rate, the economic condition of informal workers is lacking behind formal workers. Poor level of education, Poor economic strength, Physical and Mental incapability, Absence of vocational training, Gender deprivation etc. are some causes that make a larger workforce to engage in IE.

Keywords: Economic-vulnerability, Informal-economy, Northern-Province, Youth-Unemployment

The Impact of Energy Use in Agriculture and Manufacturing Value Added in Sri Lanka

Selvamalai, T.
Faculty of Economics, South Asian University, New Delhi, India
selvam3088@gmail.com

The study investigates the impact of energy use on agriculture and manufacturing value added in Sri Lanka between 1971 and 2011. The study used only three variables, energy use (Kg of Oil equivalent), agricultural value added (constant 2010 US$), and manufacturing value added (constant 2010 US$). The data was gathered from the database of World Bank. The study has applied times series econometrics techniques, especially cointegration and Granger causality test. The study founds several results. In Sri Lanka, there was no long-run equilibrium relationship between energy use, agricultural value added, and manufacturing value added. And there was a bivariate causal relationship between energy use and manufacturing value added while there was no causal relationship between energy use and agricultural value added at 5% significant level.

Keywords: Agriculture, Cointegration, Energy Use, Granger Causality, Manufacture, Value Added

Challenges faced by Dairy producers for Pursing Sustainable Livelihood in Mullaithivu District

Shivany, A.[1]*, Shathana, V. and Piriya, M.
Department of Marketing, Faculty of Management studies and commerce, University of Jaffna, Sri Lanka
**shanshivany@yahoo.com*

Dairy farming contributes to the rural economy by the way of production of organic fresh milk, milk based products, and the addition to the supply of draught power (bio-gas). It also ensures the supply of valuable nutrients and provides self-employment opportunities to the people. The fresh milk production identified in Mullaitivu as a livelihood source and uplift the living standards of resettled families through government and non-government projects. This district was badly affected by the thirty-year conflict, which ended in May 2009. People were subjected to multiple displacements and numerous lost their livelihoods. Several people in Mullaithivu district have transformed their livelihoods, for their subsistence. Many rumors stated that the dairy farmers in this district have bearable livelihood, but in real it has not been accomplished, even though they are experienced in dairying and crop agriculture, and many assistances were offered. This study focuses to identify the challenges faced by dairy producers for pursing that level. Data were collected from 35 dairy farmers through Participatory Rural Appraisal Method (PRA) via qualitative methodology. This applied marketing researched categorized the challenges as marketing problems, investment problems, problems for managing cattle, lack of research in dairy production, social and cultural barriers, and the lack of networking system. There are many weaknesses identified at the farmers' level for achieving their target. Lack of integrated system in dairy sector management in post conflict areas should be linked in into a social network system for managing livelihood at the sustainable level.

Keywords: Dairy producers, Participatory Rural Appraisal (PRA), Sustainable-livelihood

The Suitability of Market Oriented Agricultural Advisory Service (MOAAS) for Small Scale Agro Enterprise Development in Sri Lanka

Fernando, W.H.R.E.[1], Hitinayake, H.M.G.S.B.[2], Widanapathirana, C.U.[3]* and Kotagama, H.B.[4]

[1]*Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka,*

[2]*Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka,*

[3]*Division of Entomology, Department of Export Agriculture, Central Research Station, Matale, Sri Lanka,*

[4]*College of Economics and Political Science, Sultan Qaboos University, Oman*

**chinthakauw@gmail.com*

One of the constraints associated with the general farming community of Sri Lanka is inability of farmers in adapting to the volatile market situations. Market oriented Agricultural Advisory Services (MOAAS) are knowledge based prediction systems that is successfully used in many countries as effective advisory services in strengthening the peasant farmer to identify and cater the market need, considering current market pattern with multiple approaches, focusing the development of overall production chain through securing new markets. This preliminary study intends to develop an operational tool using simple linear mathematical programming to predict commercial information to use it as supportive equipment for MOAAS to assess the use and suitability of MOAAS under practical farming operations based on a randomly selected small groups of small scale farmers from four areas of Sri Lanka. MOAAS was used to find the best crop-animal combination with the lower and upper limits, reduced cost, allowable increase and decrease, practical alternative agricultural options. Farming activities were intensively studies to compare the commercial aspects of the venture before and after the programme was implemented and to evaluate the progress. It was concluded that the MOAAS programme offered promising results in cost reduction and increasing the average income per unit. The results show that the MOAAS programme can be continued with improvements suggested, expecting positive outcomes.

***Keywords*:** Extension, Market oriented Agricultural Advisory Services (MOAAS), Small scale farming community, Sri Lanka, Peasant

Pricing-to-Market and Exchange Rate Pass-Through Analysis of Sri Lankan Desiccated Coconut Export Markets

Maria Dorin, M.* and Sooriyakumar, K.
Department of Agricultural Economics, Faculty of Agriculture, University of Jaffna.
**mdorin129@gmail.com*

This article analyses the pricing to market strategy for Sri Lankan desiccated coconut export market. Market fluctuation in the value of the Sri Lankan Rupees can alter the prices of exported goods in terms of foreign currencies. Therefore, it leads to the Sri Lankan products either more or less expensive or cheaper to foreign buyers and consequently affecting export demand. Therefore, it is threatening to keep steady international export market for Sri Lankan desiccated coconut and to take the production decision when demand frequently fluctuates. The analysis of pricing-to-market **(**PTM) effects is therefore an important element in assessing the relationship of exchange rate and export prices of tradable goods. A within model is used to analyze the short-run pricing-to-market and between model is used to analyze the long-run pricing-to market. Both models of panel regression is used for analyse the exchange rate pass through of Sri Lankan desiccated coconut in the world market. Seven export market destinations were selected for analysis. This study, investigated the effects of exchange rate volatility on export market price of Sri Lankan desiccated coconut during the period 2003-2014 and viability of expanding the Sri Lankan desiccated coconut market in future. The results (Coefficient) indicate that the complete exchange rate pass through occurs in the export market of desiccated coconut in Sri Lanka in the short-run. 1% of depreciation of Sri Lankan currency in terms of foreign currency units causes to downward the export market prices of desiccated coconut by 2%. These results clearly imply that the short-run pricing-to market is a strategically viable plan to expand the Sri Lankan desiccated coconut market via exchange rate pass through.

Keywords: Between regressions, Desiccated coconut export, Pricing-to-market, Within regression

Living with Tears - *Adivasis* in Kerala

Jiji Paul, S.
Department of Political Science, Mar Dionysious College, Pazhanji, Thrissur Dist, Kerala State, India.
jiji_tvmp@yahoo.com

The present study was conducted to evaluate the socio-economic and political background of the *"Adivasi"* communities in the state of Kerala. The term "*Adivasi*" refers to the indigenous people of India who possess distinct identities and cultures often linked to certain territories. The term is derived from the Hindi word "*adi*" which means "early times" or "original" and "*vasi*" means inhabitant or residents. More than one third of the *Adivasis* of Kerala State resides in Wayanad district and others are living Attappady area. *Adivasi* communities, numbering 136,062 (17.4% percent of the total population of the district) live in Wayanad district. They are made of Paniyan (44.8%t), Mullu Kuruman (17.5%), Kurichian (17.4%), Kattunaickan (9.9%), Adiyan (7.1%) and Urali Kuruman (2.7%). In Attappady more than 90 percent of the tribal population lives below poverty line. Kurumba a primitive tribal group in Kerala live under extreme poverty. Adiya, Paniya and Kattunaikan are the other tribal communities which are still seriously underdeveloped when compared with the other tribal groups. Adivasi communities are faced with high poverty, unemployment, internal displacement, lower levels of literacy and less access to health services. Most *Adivasi* live under poor hygienic condition. They faced with low life expectancy, low nutritional intake, high morbidity and high infant mortality rate. Human Right violations such as sex abuses are common in *Adiviasi* communities. In recent times, tribes in Attappady hills have received a high publicity due to the infant deaths in the tribal hamlets in Attappady district. Lifestyle and livelihood of most *Adivasi* are dependent on forest and agriculture. Adivasis have become landless due to the large scale migration of people from the other districts. As a result tribal people in Kerala have lost their cultural living style and freedom they were enjoying and are now living with tears. Climate changes impacts and environmental problems such as deforestation have worsened their case.

Keywords: Attappady, Living standards, Kerala, Poverty**,** Tribal communities

Distribution and Carbon Stock Estimation of Mangrove Species in Kokkilai Lagoon of Mullaitivu District in Sri Lanka

Vinoth, A.[1]*, Sivachandiran, S.[1], Pushpakumara, D.K.N.G.[2] and Sivanathwerl, T[2]
[1]*Department of Agronomy, Faculty of Agriculture, University of Jaffna, Sri Lanka,*
[2]*Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka*
**vino.idm@gmail.com*

The aim of this study was to assess the diversity of mangrove tree species and to estimate above ground biomass in mangrove-forested areas. While there has been extensive research on mangroves both in tropical and sub-tropical regions of the world, there is limited available information on the community structure and carbon stock of mangroves in Mullaitivu District. The community structure, species diversity, and aboveground biomass of mangroves were estimated and distinct community types were identified. Aboveground biomass was estimated as the product of tree volume and wood density. Four very common species, two common species and one rare species and six mangrove associates were documented from seven locations distributed randomly over lagoon. Four communities had *Avicennia marina* (Forssk.) Vierh. as dominant species but with different structure and habitat. Among the sampled locations, Karunaddukerny had the highest number of species. More numbers of *A. corniculatum* (L.) Blanco seedlings and saplings were observed compared to other species. Seedling population was higher than the sapling population and this may be due to the anthropogenic activities**.** In general the forest was dominated by small sized trees, maximum mean height was 5.5 m and highest mean dbh was 27.6 cm which indicates that forest has not reached the climax stage. Estimated total carbon stock in study area was 54.89 t/ha. Maximum mean carbon stock was exhibited by *A.mariana* (25.28 t/ha) and least carbon stock was exhibited by *A. corniculatum* (0.64 t/ha). The people have been benefited from this ecosystem throughout the year such as medicinal, fuel, timber and other products and it is a breeding sites for fauna especially shrimp and crabs. However, major threat for mangroves were harvesting of sapling and parking of boat.

Keywords: Carbon stock, Distribution, Diversity, Kokkilai lagoon, Mangrove

Ecosystem Services of Homegarden Agroforestry in Jaffna Peninsula

Jeyavanan, K.[1]*.,Sivachandran, S[1]. Pushpakumara, D.K.N.G[2].and Weerahewa, J.[3]
[1]*Department of Agronomy, Faculty of Agriculture, University of Jaffna, Sri Lanka,*
[2]*Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka,*
[3]*Department of Agricultural Economics and Business Management, Faculty of Agriculture, University of Peradeniya, Sri Lanka*
**kjvanan@gmail.com*

Homegarden agroforestry systems is an integrated land management and multifunctional system that provides ecosystem services, namely provisioning, regulating, cultural and supporting. As in other areas of the country, homegarden agroforestry has received little attention from policy makers and research institutes. Hence, study was carried out in Jaffna peninsula in dry zone area of Sri Lanka to assess the ecosystem services of homegarden agroforestry. Participant observation, interview of householders, measuring and collection of biodiversity data, photographing and sketching the structure of homegardens and focus group discussion were approached to obtain the meaningful decision on ecosystems services. İn samples of 125 homegardens, a total of 5,920 individuals for flora were assessed from 58 families and 135 species. Mean value of Shannon-Wiener diversity index (H), Simpson diversity index (D) and evenness (E) for the floristic component were 1.72±0.04 (0.2-2.95), 0.78±0.12 (0.27-1) and 0.81±0.01 (0.12-1.19), respectively, revealed that the homegardens had medium, equally distributed floral diversity in Jaffna homegardens. A total of 754 individuals for domestic fauna were identified from 19 species and 12 families, H, D and E were 0.21±0.03, 0.16 ±0.03.and 0.22±0.03, respectively, revealed that faunal component had low species diversity and not equally distributed among the homegardens Mean above ground carbon stock was 40.51±3.67 (235.71-0.33) Mg C ha^{-1}. Provision of fruits was high with mean of 2,996 kg per ha and nuts from coconut was 1, 444 nuts per ha. Mean production of milk from goat and cattle were 0.44 and 1.09 litre per day per animal, respectively. Mean volume of producible trees and poles were high accounted as 36.68 and 2.12 m^3 per ha per homegardens, due to high species density. Annual mean production of fodder for livestock was 875.99±395.4 kg per ha, revealed that about 3.68 % of feed requirement could be met for livestock. There were more than 30 medicinal plants including trees, shrubs and vines used in ethno medicine. Annual mean income from both plants and animals was Rs. 20,369 per year per homegarden. Host per pollinator and pollinators per host were high in bees and mango, respectively. The temperature and shade was medium-cool and medium-high, respectively in inside the homegardens, revealed that tree canopy play a key role to regulate the environment. Different conservation practices on soil, water, nutrient and biodiversity was medium, low-medium, medium and low, respectively. Homegarden provides the habitat for flora and fauna including decomposer to support the ecosystem services. Attractive landscape features, scientific advancement and research need to be addressed for cognitive development through the process of replacement, substitution, expansion and management in the peninsula.

***Keywords*:** Agroforestry, Ecosystem Services, Homegarden, Jaffna Penisnsula

Species Diversity, Distribution and Biomass Estimation of Selected Sites of Forest Reserve in Mullaitivu District in Sri Lanka

Thirukkumaran, S*., Sivachandran, S. and Jeyavanan, K.
Department of Agronomy, Faculty of Agriculture, University of Jaffna, Sri Lanka
**shanmugaratnamkumaran@gmail.com*

The Mullaitivu district covers approximately 8.6 % of forest vegetation which contributes for the economic development of the rural community and environmental conservation of the district. However, information is scanty on species diversity, their distribution pattern and contribution for carbon sequestration of the forest ecosystems in Mullaitvu district. Hence, a study was conducted in selected areas of the reserved forest in Mullaitivu district located in the dry zone of Sri Lanka with the objective of assessment of the diversity of woody plants, their distribution and estimates the biomass. Field assessment was conducted in six locations of the forest, namely *Kulamurippu*-A, *Kulamurippu*-B, *Puthukudiyirupu*, *Nagansolai*, *Andankulam* and *Theravil*. Above ground and below ground biomass of trees were estimated using tropical allometric equation. Sampling plots were randomly selected from each location at a size of 20 m × 20 m with three replicates. Samples were collected and herbarium specimens were prepared and submitted to the National Herbarium, Royal Botanical Garden, Peradeniya for species identification. A total of 31 woody tree species and six lianas were identified from 20 families. Shannon diversity index and evenness for the tree species were 1.94±0.11 and 0.91±0.01, respectively, revealed that tree species were equally distributed with medium species diversity. Eight species, namely *Chloroxylon swietenia* DC. *Diospyros affinis* Thw., *D. ebenoides* Kosterm., *D. ebenum* Koenig., *Drypetes sepearia* (Wight & Arn.) Pax & Hoffm. *Manilkara hexandra* (Roxb.) Dubard, *Memecylon petiolatum* Trimen ex Alston. and *Vitex altissimamilla* L. f. were commonly distributed in the study sites. The forest was dominated by *D. sepearia* followed by *M. hexandra*. About 21 woody tree species were identified in *Puthukudiyiruppu* site out of 31 species, revealed that the location has highest species richness than other sites. Mean carbon stock of the forest reserve was 206.34 ±19.12 Mg C ha^{-1}, shows that mean carbon stock of the forest was higher than other dry zone forests (92.62 Mg C ha^{-1}) and lower than wet zone forest (336.8 Mg ha^{-1}) in Sri Lanka. Out of identified species, five, four, three and eight species were identified as vulnerable (VU), near threaten (NT), endangered (EN) and least conservation (LC), respectively. Results of the study provide baseline information for formulation of conservation and management guidelines for forest ecosystems in Mullativu district.

Keywords: Aboveground biomass, Carbon stock, Diameter, Reserved forests

Analysis of Participation of Active Fishers in the Production of Inland Fisheries and Aquaculture in Sri Lanka

Baweithra, U.
Strategic Planning & Statistical Unit, Eastern University, Sri Lanka
umabawei@gmail.com

Inland Fisheries and Aquaculture (IFA) contribute about 25% to the world's production of fish. Development of IFA in Sri Lanka has been given high priority by the Government. Sri Lanka plans to double inland fisheries production by supporting aquaculture to make up for dwindling ocean fish stocks. It will ensure production of fish as a cheap source of animal protein for the rural communities and it has the potential to increase income and employment opportunities for the low-income people. So, it provides livelihood to the rural communities in the interior districts. The main aim of this study is to investigate the participation of the active fishers (engaged in IFA among fishing households) in the production of IFA based on their province. The data was obtained from the Performance Report 2015 of National Aquaculture Development Authority of Sri Lanka (NAQDA) and Sri Lankan Labour Force Survey 2015 of Department of Census and Statistics. The relationship between the variables was investigated by estimating odds ratios at corresponding 95% confidence interval. The results revealed that the labour force on agricultural industry among the economically active population was comparatively higher in *Uva* and North Central Provinces than the other seven provinces. The participation of active female fishers and active male fishers in IFA was comparatively higher in Northern Province and North Western Province than the other provinces respectively. Based on the comparison of active fishers and the annual production of IFA, North Western and North Central Provinces shown positive production gain and Central and Western Provinces shown negative production gain in the year of 2015 respectively. From this analysis, we concluded that the active fishers especially male fishers from the province of North Western were highly contributed to the annual production of IFA in the year of 2015.

Keywords: Inland fisheries-Aquaculture, Odds-Ratio, Provinces

Detection and Confirmation of Phytoplasma Associated with Cucurbit Species in Sri Lanka

Tennakoon T.M.N.D.[1]*, Somarathna, T.A.T.R.[2]. and Nandasena, K.D.[1]

[1] *Plant Virus Indexing Center, Department of Agriculture, Gabadawatte, Homagama. Sri Lanka.* [2] *Department of Botany, Faculty of Applied Science, University of Sri Jayawardenapura, Sri Lanka*

**nadika74@yahoo.com*

Phytoplasma is an intracellular, pleomorpic, gram positive bacteria with lack of cell wall and important for plant disease in hundreds of economically important plant species in Sri Lanka. In plants, phytoplasmas induce symptoms that suggest interference with plant development. Typical symptoms include: witches' broom of developing tissues, phyllody, virescence, bolting, formation of bunchy fibrous secondary roots, reddening of leaves and stems, generalized yellowing, decline and stunting of plants and phloem necrosis. Some of the Cucurbit species showed the little leaf disease symptoms including dwarfed, thickened and puckered leaves and shortened internodes, which were very close to pjytoplasma symptoms. This study was conducted to identify and confirm phytoplasma disease in selected cucurbit species. The DNA was extracted from disease suspected plants and were subjected to direct PCR with universal primers P1/P2. Then the DNA was again assayed in a nested-PCR. Primers P1/P7 were used in the nested PCR round 1 to amplify desired product of 1.78 kb and primers R16F2N and R16R2 were used for the second PCR to amplify the 1.23 kb size product. The phytoplasma 16SRNA region was sequenced directly with P1/P2 primers and compared by NCBI BLAST analysis. The highest homology obtained for all three crops (bitter gourd, snake gourd and ridge gourd) was Lethal wilt oil palm phytoplasma clone LWP-16S23S-P2P1 16S ribosomal RNA gene. These transcripts for all tested species showed sufficient similarity to phytoplasma query to appear on the list of hits with a very significant E value. Bitter gourd, snake gourd and ridge gourd showed 2e89 , 1e-118 and 2e-107 E values respectively with 82% , 86%. 85% identities respective to each species.

Keywords: NCBI BLAST, Nested PCR, Phytoplasma

Occurrence of Acid Rains in the Northern Region of Sri Lanka

Rajeshkanna, S.[1]* and Illeperuma, O.A[2].
[1]*Regional Agricultural Research and Development Centre, Kilinochchi,*
[2]*Department of chemistry, Faculty of Science, University of Peradeniya*
**rrsmurunkan@gmail.com*

In Sri Lanka, the only study that is available regarding occurrence of accid rains has been carried out during 1996-2003, covering all but the northern and the eastern provinces due to the ethnic-conflict during that period. It was reported that acid rains occur at several locations in the island. Hence, this attempt was made to record the occurrence of acidity of rains in the northern region of Sri Lanka. The trans-boundary air pollutants from neighbouring industrialized countries such as China and India could be possible. A study was conducted from 2013 to 2014 to determine the pH, sulphate, nitrate, calcium and magnesium ion concentrations in the rain water in five districts, namely Jaffna, Kilinochchi, Vavuniya, Mannar and Mullaitivu in the Northern Province. The rain samples were collected from 30/11/2013 to 01/02/2014 by North east monsoonal rain. The percentages of acid rains (pH <5.6) was 8.3% and the average pH in rain water ranged from 6.2 to 8.5. The rain water with lowest pH of 5.17 was recorded at Vavuniya. The average electric conductivity ranged from 9.5 to 117.9 µS/cm with minimum and maximum values of 1.08 and 492 µS/cm in Mannar and Mullaithivu, respectively. The average concentration of sulphate ranged from 2.4 to 6.3 ppm. The average concentration of nitrate ranged from 2.1 to 10.6 ppm. It was found that acid rain occurs in the Northern region of Sri Lanka, especially in Vavuniya and Mannar possibly due to trans-boundary pollution during the north east monsoon period from November to February.

***Keywords*:** Acid-rain, Air-pollutants, Northern Province, Trans-boundary

Design and Fabrication of Sand Filter to treat Greywater to use in Cottage level

Vimaladhas,V., Kannan, N., Pirabhaharan, M. and Thushyanthy, M.*
Department of Agricultural. Engineering, Faculty of Agriculture, University of Jaffna.
**tmikunthan@yahoo.co.in*

As the world's population grows and prosperity spreads, water demands increase and multiply without the possibility for an increase in supply. The amounting demand on this finite and invaluable resource has inspired creative strategies for freshwater management, including innovative techniques for wastewater recycling. Social acceptability of use of wastewater in agriculture is low leading to protests by general public. High costs associated with treatment facilities are major hindrance to the proper disposal of wastewater. Hence the objective of this study was to construct a compact, portable sand filter treatment plant for treating the greywater and assessing its efficiency with different height of the layers. Water samples were collected from the washroom of the male's hostel located at Ariviyal Nagar, Killinochi and stored in a tank. Samples were analysed in different time during the collection to ensure there were no significant differences in the quality of the input water with time. Parameters such as COD, pH and TDS were monitored after the filtration through the filtering materials such as fine sand, coarse sand and charcoal. A compact portable sand filter was design and constructed to treat greywater. It was tested with the sand layers and charcoal at different height to analyse it's performance. The average value of measured parameters pH, TDS, and COD of greywater were 8.45, 816 mg/l and 386ppm, respectively. Out of these values pH and TDS were closer to the maximum recommended values of tolerance limits for industrial wastewater discharged on land for irrigation purpose. COD values are not higher or closer to the maximum recommended values, but they were reduced by the sand filter to the lower levels. The pH of the inlet (8.45) water was reduced to the near neutral (7.02) by the sand and charcoal filter. It was effective with the charcoal rather than sand alone. The average TDS in the greywater was 816 mg/l. Mean reduction of the TDS was 320 mg/l. The average COD value from the untreated water was 386ppm and it was reduced to 211ppm in the final outlet. There were no significant difference in COD with increasing height of the filter material at $p<0.05$ level. There were significant differences in raw, filtered through fine sand and charcoal filter materials. Finally the sand layers along with charcoal had the significant reduction in all measured parameters and all the parameters were bring down to the recommended values of the tolerance limits for industrial wastewater discharge on land for irrigation purpose.

Keywords: Sand filter, Greywater treatment, pH, Chemical oxygen demand, Electrical conductivity

Isolation and Identification of Oil Degrading Bacteria

Vasanthiny, J.[1] Prabhaharan, M.[1], Balakumar, S.[2] and Thushyanthy, M.[1]*
[1]*Department of Agricultural Engineering, Faculty of Agriculture, University of Jaffna,* [2]*Dept. of Biochemistry, Faculty of Medicine, University of Jaffna*
**tmikunthan@yahoo.co.in*

Bioremediation has received a great deal of attention, and bacteria isolated from polluted soil can be used in bioremediation process. The Jaffna peninsula depends to a great extent on groundwater resources for domestic as well as agricultural purposes. On several instances it was pointed out that, the groundwater is deteriorating due to over misuse and it is polluted by the excessive usage of agrochemical, fertilizers, and improper disposal of waste oil and sewage. Hence an experimental study was undertaken to isolate the oil degrading bacteria from natural environment to facilitate the biodegradation to degrade the waste oil contamination site. Soil samples were collected from oil contaminated site as near to automobile service station, Kondavil, Jaffna. Inoculum was prepared and incubated in the culture media, which grow on a medium with oil as the sole carbon source. Colonies were separated based on their morphological characters with the help of microscope. Isolated bacterial strains were identified through gram staining, motility, aerobic and anaerobic growth. For further classification and identification, biochemical tests were done. From the contaminated soil, 10 morphologically different bacterial strains were isolated and strains were identified as *Pseudomonas alcaligenes, Micrococcus spp, Bacillus subtilis, Pseudomonas stuzeri, Streptococci pyogenes, Bacillus megaterium, Pseudomonas mendocina, Bacillus firmus, Bacillus cereus* and *Acinetobactor spp.* The results revealed that crude oil degrading bacteria from soil environments have a high level of diversity and variable biodegradation abilities. Oil degrading bacteria can be isolated from oil-polluted sites. These bacteria are indigenous in the polluted sites and they are responsible for the degradation of oil. These isolated bacteria could be used for bioremediation effectively in the oil-contaminated sites. Further studies are required to identify the cocktail of selected bacterial strains to efficiently carryout bioremediation of the contaminated soil and effluents from the automobile service stations.

Keywords: Oil degrading bacteria, Isolation of bacteria, Identification of bacteria, Bioremediation

Trend analysis of Annual and Seasonal Rainfall Data of Kilinochchi District

Haranrajah, J.*, Thushyanthy, M. and Srivaratharasan, T.
[1]*Dept. of Agricultural Engineering, Faculty of Agriculture, University of Jaffna*
[2]*Dept. of Biochemistry, Faculty of Medicine, University of Jaffna*
**tmikunthan@yahoo.co.in*

Rainfall is a scarce and an important hydrological variable in dry zone areas. The need for water in these areas increases daily due to population growth, economic developments, and urbanization and consequently, water management using all the available resources is becoming increasing crucial. In order to develop an effective water management strategy for Kilinochchi, trend analysis of annual, monthly and seasonal rainfall is important. Hence the objective of the study was selected as trend analysis of annual, monthly and seasonal rainfall of Kilinochchi district. Monthly rainfall data of Killinochchi district from 1921 to 1981, 1999 to 2007 and 2012 to 2014 was collected from the Department of Meteorology, Sri Lanka. Altogether 73 years of data were used in this analysis. The annual total rainfall in Kilinochci is normally distributed. The average value of rainfall was 1372 mm and there were no cyclic changes or linear trends observed during the study period. The highest rainfall of 2132 mm and the lowest value of 574 mm were observed during 1965 and 1974, respectively. The trend suggests a fluctuating and general decline in rainfall values in recent times over the study period but not significant. Results of the dependable rainfall and probability of exceedance of 80% rainfall was positive in the months of January, March, April, May, October, November and December. This value ensures that on average, there will be enough water to meet the crop's need four out of every five years during the above months. Trend of moving average of 3-Point for annual rainfall, first inter monsoon, Southeast monsoon, second inter monsoon and Northeast monsoon showed negative trend and the modal was not significant in all cases. The logarithmic model was fitted for the relationship between return period and rainfall amount for annual, first inter monsoon, Southwest monsoon, second inter monsoon and Northeast monsoon. Overall Standard Precipitation Index (SPI) values that lied on the dry event symbolize a significant increasing trend where as all SPI values that lied on wet events have shown an overall decreasing trend. The result of the analysis could be used for water management strategies.

Keywords: Rainfall analysis, Kilinochchi, Dependable rainfall, Probability of exceedance

Study on Physical, Proximate and Fatty acid Profile of Medium Seeded Groundnut *(Arachis hypogaea* L.*)* Varieties and Promising Lines in Sri Lanka

Ranathunga, R.A.A.*, Amarasinghe, Y.P.J. and Gunasekara, G.T.N.
Grain Legume and Oil Crops Research and Development Centre, Angunakolapalessa, Sri Lanka
**raaranathunga@gmail.com*

The information related to physical properties, chemical composition and fatty acids profile of medium size groundnut grown in the country are scarce. Therefore, the present study was designed to determine above mentioned properties of some commonly grown groundnuts cultivars and promising accession in Sri Lanka. Selected medium size groundnuts varieties (Indi, Tikiri, Tissa and ANKG1) and promising lines (ICGV01276, ICGV 00073 and ICGV 86590) were planted as randomized complete block design with two replicates. Physical properties such as numbers of kernels, pod beak, reticulation, testa colour, and shell out percentage varied considerably among groundnuts varieties and line. Moisture (5.4-8.4%), crude protein (18.7-28.5%), lipid (43.4-53.0%), ash (4.4-5.8%), carbohydrates (9.3-18.2%) and energy level (565.7-618.2kcal) contents varied considerably among the tested varieties, and also showed a significant difference among varieties. The quality and flavor of edible groundnuts and its products is highly affected by fatty acid composition of oil. Lipids profile of groundnuts were mainly composed of mono and polyunsaturated fatty acids (>78% of the total lipids). Fatty acid composition analysis indicated that oleic acid (C18:1) was the main constituent of all tested varieties except the variety ANKG1, where linoleic acid (C18:2) was the major fatty acid. The saturated fatty acids palmItic, stearic acid and behenic acid in different cultivars ranged between 10.2 -15.6%, 2.5 - 6.3% and 1.1- 5.3%, respectively. Differences among cultivars for oleic acid exhibited significance which ranged between 38.2 to 47.4%. Similarly, cultivars differed statistically for linoleic acid which showed a range of 23.1 to 38.7%. Oleic to linoleic acid ratio was differed and all the released varieties were below the minimum standard level of 1.6, whereas ICGV 86590 and ICGV 00073 showed higher O/L ratio of 1.94 and 1.75 respectively. Finally, it can be concluded from present investigation that groundnut varieties and accessions grown in the country match the international quality standards in terms of physical, proximate composition and fatty acid composition.

Keywords: Fatty acid, Groundnut, Medium-seeded, Promising lines, Sri Lanka

Effect of Thermal Treatment on Keeping Quality of Palmyrah Sweet Sap

Surenther, S.[1], Mahilrajan, S.[2]*, Chandrasena, G.[1], Robika, K.[2] and Sri Vijeindran, S.[2]
[1]*Uva Wellassa University, Badulla, Sri Lanka*
[2]*Palmyrah Research Institute, Kandy Road, Jaffna, Sri Lanka*
jsubajini@gmail.com

The palmyrah palm (*Borassus flabellifer* L.) is grows extensively in Northern part of Sri Lanka. It is called as 'Tree of life' has contributed immensely to the people both as food and shelter and also the base for income generation. The most important product of palm is the sap or juice. It should be extracted from both male and female inflorescences (dioecious plant) by the process known as tapping.Harvested sap should be immediately processed due to the highly perishability as it under goes spontaneous fermentation via air born yeast microflora. The main objective is the study was to identify the optimum temperature and time for preservation of sweet sap and detected the suitable shelf life for bottled sweet sap via the physical, chemical, microbiological and sensory quality of preserved sweet sap. Traditionally quick lime is added to prevent the fermentation; phosphoric acid was selected at pH 8 for the removal of lime as calcium phosphate. Delimed sweet sap was used for the study of thermal treatment in order to increase the keeping quality of palmyrah sweet sap. Three experiments with different thermal treatments were conducted to preserve the sweet sap. Experiment 1(preservatives such as citric acid and sodium metabisulphite) and Experiment 2 (thermal treatments of 60, 70 80 and 90^{o}C) were rejected through the microbiology and sensory evaluation. In the 3rd experiment the bottled sweet sap was heated at 105, 110 and 115^{o}C for different time intervals (15 and 30min) and stored at room temperature. There were no significant differences ($p<0.05$) in chemical, physical and microbial evaluation of selected treatments at 60 days of storage. Based on sensory evaluation, Treatment 5 thermal processing at 105^{o} C for 15 min was selected as the best treatment and it could be stored for 60 days without changing its native characteristics.

***Keywords*:** Palmyrah, Preservation, Sweet sap Temperature and Time

Improvement of Product Formulation of Palmyrah Fruit Cordial available in the Market

Nilushiny, A.M.*, Mary, J. and Sri Vijeindran, S.
Palmyrah Research Institute, Kandy Road, Kaithady, Jaffna, Sri Lanka
**nilushi1985@gmail.com*

The tropical palm Palmyrah (*Borassus flabellifer* L.) is commonly found in north-east of Sri Lanka. Fully ripen fruits of the palm are extracted and bottled during the peak harvesting season from August to October every year. Palmyrah fruit cordial, produced by Palmyrah Development Board of Sri Lanka, is readily available at its sales centres but the quality of the existing product needs to be improved to attract the national and international markets. Therefore, a research study was carried out to improve the product formulation according to the recommendations of the Sri Lanka Standards Institute (SLS 214: 2010). Ingredients of Palmyrah fruit pulp, cane sugar, tartaric acid or citric acid, pectin and sodium metabisulphate were used and all ingredients were added as fruit pulp, sweetener, acidulant, stabilizer and preservative respectively. Product development was performed by changing one ingredient at different percentages while maintaining others at a constant level in each production step. However, firstly, fruit pulp and cane sugar were changed as combination since pulp had bitterness. Amount of pulp and cane sugar combinations used for optimization were 25, 30 and 35% of fruit pulp each with 40, 45 and 50% of cane sugar. In the following steps as optimizing amount of pectin from the percentages of 0.025, 0.05, 0.075 and 1 %, best amount of citric acid and tartaric acid among percentages of 0.2, 0.4, 0.6, 0.8 and 1% and proper amount sodium meta bisulphate among 50, 100, 150 and 200 ppm, optimized amount of ingredient in former step was added to the mix. A sensory evaluation was conducted after dilution of cordial to four times. It was performed with 30 untrained panelists using a 5-point hedonic scale and the results were analyzed by Minitab 16.0 software. The Friedman non-parametric test was used to select the best product and the mean separation was performed by Tukey's Test at p=0.05. Formulated and improved product contained cane sugar, palmyrah fruit pulp, water, pectin, citric acid and sodium metabisulphate at concentrations of 40%, 30%, 29.15%, 0.05%, 0.80% and 200 ppm respectively on weight basis (w/w). Acidity as citric acid percentage and the brix value were also determined as 0.38% and 13.21^{o}, respectively. These values complied with the SLS 214:2010 standards showing that reconstituted product contain both values below 1% and 16^{o}, respectively. The shelf-life of the product was determined to be for six months in different heat treatments of temperature and time combinations of 70^{o} C, 80^{o} C and 90^{o} C for 10 and 20 min for each step. Acidity, pH and brix values ranged between 0.3- 0.4%, 3.0- 3.3 and 12.8- 14.3 during six months of storage period for all the heat treatments applied. Microbial test results had stated that 80^{o}C for 20 min could be selected as heat treatment for bottling to keep the product for six months without deteriorating its quality.

Keywords: Cordial, Palmyrah fruit pulp, Shelf life, Sri Lanka Standards

Naringinase Producing Bacterium from Decaying Bitter Citrus Fruit (*Citrus medica*)

Keerthini, S.[1]*, Kapilan, R.[2] and Vasantharuba, S.[1]

[1]*Department of Agricultural Chemistry, Faculty of Agriculture, University of Jaffna, Sri Lanka,*

[2]*Department of Botany, Faculty of Science, University of Jaffna, Sri Lanka*

keerthinisrikantha58@gmail.com

Naringin is a major component found in all parts of citrus family trees and is responsible for the bitter taste of their juices. Microorganisms that are associated with citrus family fruits appear to have the ability to produce extracellular naringinase enzymes which can degrade the naringin thereby reducing its bitterness. This study was aimed to isolate the naringinase producing bacteria from bitter citrus fruit (*Citrus medica*) to debitter its juice and to identify the best naringinase producing bacterium. Initially the naringinase producing strains were isolated from decayed bitter citrus fruit and the soil where fruit is allowed to decay, using selective medium which was naringin agar medium. Totally, seven strains were selected from the medium and out of which four strains (BIC2, BIC3, BIC5 & BIC7) showed positive responses to qualitative naringinase assay and they were selected for further studies. These selected bacterial strains were subjected to liquid fermentation medium for 60 hours at 37ºC at 120 rpm and the produced crude enzyme was tested for naringinase enzyme activity at pH 5 and 50 ºC for 10 minutes. Out of the four selected strains, the strain BIC3 showed the best naringinase activity (1.225µmol/ml/min). Since the solid state fermentation system provided natural habitat for bacteria, the naringinase activity was optimized via solid state fermentation system using paddy husk as the support at 37ºC and pH 7 for 60 h. Based on the morphological, microscopical and biochemical tests, the selected strain BIC3 was identified as *Enterococcus* sp and the highest activity (302.54Ug^{-1}Dry Matter) was obtained after 48th hours of fermentation at 37ºC and at pH 7. Therefore *Enterococcus* sp. could be used to produce large scale naringinase enzyme under solid state fermentation system using paddy husk as support, after the optimization of the culture conditions.

Keywords: Bitter citrus fruit*,* *Enterococcus* sp, Naringinase, Paddy husk, Solid state fermentation

Isolation and Characterization of Naringinase Producing Bacteria from Palmyrah (*Borassus flabellifer* L.) Fruit Pulp

Sinthuja, K.*, Kapilan, R. and Vasantharuba, S.

[1]*Department of Agricultural Chemistry, Faculty of Agriculture, University of Jaffna, Sri Lanka,*

[2]*Department of Botany, Faculty of Science, University of Jaffna, Sri Lanka*

**renisinthu@gmail.com*

Palmyrah (*Borassus flabellifer*) fruit pulp is known to have good nutritive and health beneficial properties. However the consumer acceptance of the pulp is low due to its bitter taste caused by a compound named as flabelliferin. Naringinase enzyme has the ability to hydrolyze this flabelliferin into non bitter aglycone and sugars. This study was aimed to isolate naringinase producing bacterial strain from Palmyrah and characterize the best naringinase producer. The naringinase producing bacterial strains were isolated from decaying palmyrah fruit pulp and the soil where pulp was allowed to decay, using the selective medium named Naringin Agar Medium. The crude naringinase enzyme activity was determined through the production of glucose by hydrolysis of flabelliferin using naringinase enzyme. Three bacterial strains designated as PB1, PB2 and PB3 were identified as naringinase producers through primary screening by qualitative naringinase assay. These bacteria were subjected to naringin liquid fermentation medium (LFM) for 48 h at 37ºC at 100 rpm and solid state fermentation system (SSF) using paddy husk as a support for 48 h at 30±2ºC and the crude naringinase enzyme activity was assayed at pH 5 and 60 ºC for 10 min in all the cases.The bacterial strain (PB1) was selected as the best producer based on the enzyme activities obtained in the LFM (0.936U/ml after 30 h of incubation) and SSF (239.55U/gram of dry substrate after 48 h of incubation at 30±2ºC).Based on the cellular and colony morphology, microscopic and biochemical tests done, the selected strain PB1was identified as *Staphylococcus* sp. Large scale liquid and solid state fermentation studies and molecular analysis should be done to confirm these findings.

Keywords*: Borassus flabellifer*-pulb, Flabelliferin, Naringinase, Paddy husk, *Staphylococcus* sp.

Studies on Identification of Different Species of Brown Seaweeds available in the Coastal Region of Jaffna Peninsula

Thirsigayini, S.[1]*, Vasantharuba, S.[1] and Thavaranjith, A.C.[2]
[1] *Department of Agricultural Chemistry, Faculty of Agriculture, University of Jaffna, Sri Lanka,*
[2] *Department of Botany, Faculty of Science, University of Jaffna, Sri Lanka*
**thirsigayini@gmail.com*

Seaweeds are macroscopic algae, which form an important component of the marine living resource. Brown algae are economically important type of seaweeds which can be utilized in the food industry and clinical medicine. Quantitative surveys carried out in the early eighties reviewed that extensive beds of brown seaweeds were found in coastal region surrounding the Jaffna peninsula. Therefore, this study was carried out to identify the sites in Jaffna peninsula which are currently rich in brown seaweeds and to identify the important species in these regions. Initially three visits were made along the coastal area of Jaffna peninsula to identify the sampling sites of brown seaweeds. Coastal regions of Allaipiddy, Mandaitivu and Karainagar were selected as the sampling sites based on the availability of brown seaweeds. Sample collection was made from the coastal edge up to 100 m towards the ocean. Collected samples were identified based on their morphological, anatomical and reproductive features with the help of standard key in the laboratory. Five different species of brown seaweeds each were identified in the coastal region of Allaipiddy, Mandaitivu and Karainagar. A total of 7 different species of brown seaweeds were identified from these sites. The identified species of brown seaweeds include *Sargassum tennerimum, Sargassum polycystum, Turbinaria ornata, Turbinaria conoides, Turbinaria murayana, Padina gymnospora,* and *Canistrocarpus crispatus*. Further studies need to be carried out to find out the potential uses of identified species.

***Keywords*:** Brown seaweeds, Coastal region, Jaffna peninsula, Species

Evaluation of Different Green Leaf Manures against Onion Stem and Bulb Nematode (*Ditylenchus dipsaci*) and Bulb Mite (*Rhizoglyphus* sp.)

Piratheepa, J.* and Mikunthan, G.
Department of Agricultural Biology, Faculty of Agriculture, University of Jaffna
**jtheepa90@gmail.com*

Onion is an important cash crop in Sri Lanka. Among the onion varieties, small onion is mostly cultivated by farmers in Jaffna because it gives high profit. Even though, pests and diseases are the major limiting factors. Among the onion pests; stem bulb nematode and bulb mite were reported as very important and their management is very difficult and mainly depend on chemicals. Therefore, a research was aimed to evaluate the effects of different green leaf manures on the population of *Ditylenchus dipsaci* and *Rhizoglyphus spp* in the onion. A nematode infected farmer field was selected for the field trial. Well prepared land was treated with different green leaf manures such as *Gliricidia maculate, Calotropis gigantia, Glycosmis pentaphylla, Thespesia populnea* and *Azadiracta indica* and allowed for fifteen days for complete decomposition. Onion bulbs were planted. Onion bulb samples were collected weekly and analyzed for nematode and mite population by using stereomicroscope in the laboratory. The results showed that *G. maculate* reduced the nematode population in significant amount from second to sixth week in the onion bulbs. Mite population was also reduced in significant amount by the *G. maculate* from second to sixth week in the onion bulbs. *C. gigantia, T. populnea* and *A. indica* showed considerable reduction in nematode and mite population.

***Keywords*:** *Ditylenchus dipsaci*, Green leaf manures, Onion, *Rhizoglyphus sp*

Public Trust Doctrine: Constitutional Safeguards and Judicial Interpretations towards Healthy Agriculture

Deshani Thabrew, K. C.
Department of Law, Faculty of Arts, University of Jaffna, Sri Lanka.
chinthikatabrew@gmail.com

Effectiveness of modern agriculture and rapid environmental degradation is a matter that has to be addressed when dealing with the topic of environmental protection under the area of law and agriculture. Constitution of Sri Lanka provides few mechanisms to protect environment and Public Trust Doctrine (PTD) can be utilized as a remedial opportunity for challenges arising from modern agriculture. Combination of Article 3 and Article 4 of the 1978 constitution creates PTD in Sri Lanka. The doctrine states that the government is deemed to be the trustee of the natural resources of the country which must be held in the interest of people as beneficiaries. It is widely interpreted as the present generation holds the natural resources in trust for the future generations. In establishing the PTD, major lacunas can be identified in Sri Lankan legal system such as; doctrine is only recognized partially by the constitution as an entrenched provision, doctrine is vague as no specific criterions designed for its applicability, judiciary has no specific jurisdiction to deal with the matters connected with the doctrine other than the fundamental rights jurisdiction and no specific mechanism is available to people to commence litigations where the PTD is violated. The study discusses the information collected from law books, journals and articles written by public law experts to study how the application of the doctrine has to be adopted according to Sri Lankan legal framework and to overcome legal issues arising when implement the PTD. It is recommended that to adopt a people closer constitutional mechanism to safeguard the PTD as it automatically encourages the judicial activism in the country as the guardian of sovereignty in Sri Lanka.

Keywords: Constitution, Entrenched Provision, Fundamental Rights Jurisdiction, Judicial Activism, Sovereignty.

Effect of Benzyl Amino Purine on the Lateral Shoot formation of Cordyline (*Cordyline fruticosa*) Shoots

Palugaswewa, P.S.[1], Krishnarajah, S. A.[2], Mahendran, S.[1] and Puvanitha, S.[1]*
[1] *Department of Agricultural Biology, Faculty of Agriculture, Eastern University, Sri Lanka,*
[2] *Director, Research and Technology Transfer, Royal Botanic Gardens, Peradeniya, Sri Lanka.*
**spuvani@gmail.com*

Cordyline *(Cordyline fruticosa)* is an important ornamental foliage plant species belong to *Asparagaceae* family grown in the tropical and sub-tropical regions of the world. Availability of quality planting material is a major problem in cordyline cultivation. This study focussed on the induction of lateral shoots formation with Benzyl Amino Purine (BAP) on the decapitaed Cordyline plants. Cordyline shoots of about 25cm long were potted in polyethylene bags (6cm x 15cm) filled with the medium of compost and sand mixed at 1:1 ratio. Shoots were kept for three weeks in the shade before decapitation. Application of different concentrations of BAP (25, 50, 75 and 100 ppm) was done twice (3 weeks after plant establishment and 2 weeks after the first hormonal application) as a foliar spray while the control was sprayed with distilled water. The number and length of lateral shoots and the number of leaves of cordyline plants were recorded after the hormone treatment at two week interval. It was found that the application of 75 ppm BAP was the most effective in producing lateral shoots and leaves on cordyline plants. Treatment with 75 ppm BAP has given the highest number of lateral shoots (5.8 and 7.2) and leaves (14.2 and 19.3) compared to the rest of the treatments in both hormonal applications. The length of shoots was also increased markedly due to the application of hormone. The highest length (24.4 and 38.6 cm) was observed in plants treated with 75 ppm BAP. The findings of this study indicate that the application of 75 ppm BAP can be beneficial for lateral shoot induction and growth enhancement of Cordyline trees during two hormonal applications.

Keywords: BAP hormone, Cordyline plants, Lateral shoots

Variability Assessment of Morphological Characteristics of Selected Sri Lankan Traditional Rice (*Oryza sativa* L.) Varieties

Bandara, M.M.K.[1]*, Herath, H.M.V.G.[2], Wickramasinghe, H.A.M.[2] and Bamunuarachchige, T.C.[3]

[1]*Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka,* [2]*Department of Agricultural Biology, Faculty of Agriculture, University of Peradeniya, Sri Lanka,* [3]*Department of Biological Sciences, Faculty of Applied Sciences, Rajarata University of Sri Lanka, Mihintale, Sri Lanka.*

**b.krishanthi@gmail.com*

Rice is one of the most studied plants due to high genetic variation and being the major food for more than half of the world population. Sri Lankan traditional rice varieties are rich in genetic diversity and important characteristics. Before studying the genetic background of characters, a preliminary study on morphological characters is needed. This study was aimed to evaluate variability of selected Sri Lankan traditional rice varieties with respect to morphological characters. Seeds of 24 Sri Lankan traditional rice varieties and *IR64* were selected. A pot experiment with complete randomized bock design was used and five replicates were prepared. Fifteen characters were measured using standard evaluation system for rice and descriptors for rice, published by International Rice Research Institute and analyzed by multivariate analyzing tools using principal component analysis (PCA) and single linkage cluster method provided by IBM SPSS 16.0 statistical software. Selected rice varieties were grouped into 5 clusters at 15 minimum distance between clusters. Cluster I comprises twenty one varieties and other four clusters comprise single variety in each. Clustering of 21varieties (*Goda heenati, Thawalu, Al wee, Goda el wee, Pachchaperumal, Godamanel, Goda wee, Kottiyaran, Kara el, Batapola el, Pokkali, Hetada wee, Moddai karuppan, Vannam villai, Kalu heenaty, Sudu heenaty, Pola el, Kalu bala wee, Kahatawalu, Dahanala and Niyan wee*) into one cluster shows the homology of the varieties. Clustering of *IR64*, *Gonabaru*, *Rathl* and *Ma wee* in different clusters indicates their significant difference from cluster I. Five principle components (PCs) were identified as significant according to PCA. They account for 79% of total variation. PC1 accounts for 30% and PC1 and PC2 together account for 51% of variance. Selected varieties show a significant difference according to the clustering pattern. Out of descriptors used in this study, significant descriptors of PC1 to PC5 can be used to differentiate selected varieties.

Keywords: Morphological characters, Multivariate analysis, Traditional rice

Estimation of Soil Organic Carbon and its Fractions in Paddy growing soils of Northern Province of Sri Lanka

Yogenthiran, N.,[1] Ratnayake, R.[2] and Gnanavelrajah, N.[1]*

[1]*Department of Agricultural Chemistry, Faculty of Agriculture, University of Jaffna, Sri Lanka*

[2]*National Institute of Fundamental Studies, Kandy Sri Lanka*

**gnanavelrajah@yahoo.com*

Soil organic matter plays a vital role in the dry zone agriculture. Maintaining soil organic carbon not only enhances crop production but also helps to manage greenhouse effect. In this regard paddy growing soils favours accumulation of soil carbon because of flooded condition. In this study, total soil organic carbon and its fractions in paddy growing soils were estimated in the Northern Province of Sri Lanka.This study was carried out in Jaffna, Kilinochchi, Vavuniya, Mannar, Mullaitheevu districts of Northern Province of Sri Lanka. The great groups of paddy growing soils in the study area includes Calsic yellw latosols (Ustorthents), Low humic gley (Endoaqualfs) soils, yellow latosols (Ustorthents), Ggrummusols (Endoaquerts), Alluvial soils (Tropaquents), Sandy Regosols (Quartzipsamments) and Solodized Solonetz (Natraqualfs). Eighty four soil samples were collected from depths of 0-15 cm and 15-30 cm from the five districts of Northern region according to the percentages of paddy cultivation area. Total organic carbon and its fractions such as microbial biomass carbon, water soluble carbon and KMnO4 oxidizable carbon were analyzed. By overlaying the soil map and land use map in a GIS environment, extent of paddy soils in each soil great group in each district was estimated. Total organic carbon, microbial biomass carbon, water soluble carbon and KMnO4 oxidizable carbon in top soil were ranged from 0.31 - 4.73%, 0.001 - 0.069%, 0.001 -0.029% and 0.043 - 0.070% respectively. The total organic carbon in top soil of Jaffna, Killinochchi, Mannar, Mullaitheevu and Vavuniya were ranged from 0.46 - 2.73%, 0.31 - 2.75%, 1.41 - 2.97%, 0.79 - 2.07% and1.66 - 4.37% respectively. Using the average bulk density values for each great group soils, the total organic carbon, microbial biomass carbon, water soluble carbon and KMNO4 oxidizable carbon in paddy fields of Northern Province, were estimated as 6,045,299, 48,228, 43,671and 226,914 tons respectively at 0 -30 cm depth.

Keywords: Total organic carbon, Paddy soils, Microbial biomass carbon, Water soluble carbon

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