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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) that has been organized by the Faculty of Agriculture, University of Jaffna to celebrate its Silver Jubilee on October 15th and 16th, 2015.

Faculty of Agriculture at the University of Jaffna's roots took hold in 1990 at Kilinochchi, since then it faced immense problems due to the civil war. In 2014, it has been successfully re-established at 'Ariviyal Nagar', Kilinochchi after 25 years and celebrating its 25th Anniversary in 2015 in its own premises. 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 "Environmental Challenges and Cleaner Agriculture" 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. This Conference also provides a unique opportunity for agricultural experts, users and other researchers to meet, discuss the status of the research in cleaner 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-2015 for their dedication and untiring effort in making this event happen and to make it a great success.

I wish the deliberations of ICDA-2015 a great success

Professor Ms. Vasanthy Arasaratnam,
Senior Professor of Biochemistry and the Vice Chancellor,
University of Jaffna,
Sri Lanka
October 2015

Message from the Conference Chair

In commemoration of the celebration of Silver Jubilee (1990-2015) of the faculty of Agriculture, I have the privilege to give this message to the first International Conference on Dry zone Agriculture (ICDA 2015). The faculty was inaugurated by former Vice-Chancellor, Late Prof.A.Thurairajah on 3rd December 1990. Indeed, it is a milestone of the faculty to host this first conference this year after being settled at our own land and building in December 2014. This is the most affected faculty of the University of Jaffna due to the three decade unrest situation, the majority of the period was struggling with very limited facilities and non-friendly study environment. However the commitment, team work and high risk bearing ability of the staff and students of this faculty witness its growth to this height and 23 batches of students graduated and performing well in various sectors locally as well as internationally.

The faculty has a great diversity incorporating multi-ethnic, multi-cultural and multi-religious students and striving hard to excel in teaching, research and dissemination in agriculture. The leaderships of the University and the faculty in the past contributed immensely towards its establishment and subsequent development as a full fledge faculty at this level. It has developed MoU with Michigan State University, USA for exchange of staff and for training. The assistance from the World Bank through IRQUE, HETC, line ministry and other ministries of Government of Sri Lanka and the University Grants Commission, Governments of India and Japan are acknowledged and for their

wise decision to support for the infrastructure facilities for research, training and dissemination and for their continued support. We commit ourselves to support the mission of National food production and promotion of the Government to produce food by protecting the environment.

The theme selected for the conference is '*Environmental challenges and cleaner Agriculture'* is extremely relevant to the today's need. With the vision of promoting innovative research for tomorrow's development with environmental concern, this conference was organized giving platform for the researchers to document and disseminate their findings. Therefore, we trust that the conference will produce great ideas from a variety of research and exchange the knowledge of experts, colleagues and friends who are working in cleaner agriculture production with environment challenges. Development requires continuous economic growth with minimal damage to the environment.

It is understood that the success of the conference depends ultimately on the people who are with us in planning and organizing both the technical program and supporting social arrangements.

Finally, I wish to express my sincere thanks to our Guests, Keynote speakers, Authors of the research papers, Reviewers, Chairman of the sessions, Industries, Alumini members, Members of the organizing committee, Members of the editorial committee, Sponsors of various programs, Student Union, Students of the faculty and many others who volunteered to assist to make this very significant event a success.

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

Dr. (Mrs).Thushyanthy Mikunthan
Conference Chair ICDA 2015 and Dean/Agriculture

Message from the Convener

It is my great pleasure to welcome you all to this historic First International Conference on Dry Zone Agriculture. This conference is a land mark event in the history of Faculty of Agriculture, University of Jaffna which is commemorating silver jubilee this year.

Faculty of Agriculture, University of Jaffna is hosting the ICDA 2015 with the theme of "Environmental challenges and Cleaner Agriculture", which discusses the current burning issues in Agriculture and Environment. ICDA 2015 will bring together a diverse group of academics and professionals on to a common platform where they can share their scientific knowledge among themselves and take the knowledge to the world. This conference also provides an excellent forum for the budding scientists and students to receive much needed international exposure, evaluation, discussion, debate and enrich their research findings with veteran researchers in their respective fields.

The cherished memories of the inauguration of the faculty in 1990 are still green to me and being the first batch student of the faculty I am very proud to be the Convener of this conference. Further it appropriate to record that Late Prof.A.Thurairajah inaugurated the faculty and Late Prof.K.Kandiah served as the first Dean of the faculty at Kilinochchi in 1990. Displaced in 1996 to Jaffna and after twenty five years of hardships, we have returned to our permanent location at Kilinochchi and celebrating the silver jubilee year in which this conference was organized as one among them.

Being the convener of ICDA 2015, I wish to thank the Vice-Chancellor, Conference chair, Guest of honour, Plenary and Keynote speakers, session chairmen, active organizing committee members, authors, reviewers, academic and nonacademic staffs of the faculty, alumni members and students for their support and assistance. The unreserved cooperation of these members is the secret behind the success of this Conference.

While thanking all contributors who made the forum a great success, I sincerely hope this ICDA series of conference will be organized in the future years also.

Dr.S.Vasantharuba
Convener/ ICDA 2015

Message from Finance Chair

I am greatly pleased to be the finance chair in the I.C.D.A-2015 programme taking place during the 25th year since its inception. Having been made to wander from the region, displaced & thoroughly disorganized and in utter disarray ultimately the Faculty of Agriculture has finally arrived at its allocated home. This institution initiated by the effort of Prof.A.Thurairajah, is greatly indebted to him for his unstinted labour for its existence. That the faculty with its civil infrastructure is available for us today goes to the credit of a group of individuals of expertise whose concern for the progress of the region in agriculture was paramount.

It has been the practice with the other Faculties to hold conferences regularly annually. The same was not possible however with the Faculty of Agriculture due to the complication of the contemporary status quo. Nevertheless during the organization of this project we realized with surprise that certain institutions & individuals of standing were unaware of a Faculty of Agriculture in the University of Jaffna. Thus it is imperative that the Faculty of Agriculture needs exposure & display.

It is significant that members of our alumni are holding responsible posts in relevant fields throughout the globe having done differential research of a very high order. I propose here that a better organized alumni be established to construct a think tank with substantial machinery & equipment with skilled personnel. Information on membership and any technical or research findings

of the most recent variety could be made available for staff, student, farmer & people in general.

I wish to emphasize that this Titanic initial effort will be a water shed event initiating a resurrection of the Faculty to greater heights taking formidable strides in the field of food production while engaging the environmental decline all the way. I take this opportunity to thank all participants namely contributors, observers and our co-sponsors all of whom have extended their corporation beyond all my expectations, to make this event a possibility and a success

Thanks again.

Assuring of our continued fellowship at all times

K.Umashankar
Finance Chair/ ICDA 2015

Message from Conference Secretaries

As the Joint secretaries of the ICDA-2015, we extend our very warm welcome to all of you to the International Conference on Dry Zone Agriculture, 2015, at the Faculty of Agriculture, University of Jaffna. As an integral part of the conference, it has been a great honor and privilege to serve as the secretary of the conference this year.

Everyone of us is well aware that the Faculty of Agriculture at the University of Jaffna has gone through enormous troubles due to the civil war. Considering the hardships that we had in the past, this conference is a milestone of the Faculty of Agriculture and we are very much proud to organize an international conference to celebrate our silver jubilee. ICDA-2015 provides international forums for researchers from academia and industry to exchange and share their experiences, research results, and new ideas on hot and emerging topics on Agriculture. This year we enjoyed the great privilege to have worked with researchers across the country covering a variety of topics. The conference theme "Environmental Challenges and Cleaner Agriculture" well suits today's needs. The health and wealth of a nation and its potential to develop and grow depend upon its ability to feed its people. Agriculture, as a primary activity, is directly connected to food availability. However at the same time, productivity increases or the use of new areas for cultivation and livestock, have a cost in terms of sustainable development. Considering the current issues we have selected the theme and it has been very much welcomed by the academia.

Many people have made contribution to the workshop. We would like to thank the authors who expressed interests and submitted their papers to the workshop. Their efforts have been the driving force of this conference. We would like to express our deepest gratitude to the panel of reviewers, who provided timely reviews for the papers despite the tight schedule. We wish to thank our Vice-Chancellor, Senior Prof. Vasanthy Arasaratnam and the Dean/Faculty of Agriculture, Dr. (Mrs.) Thushyanthy Mikunthan for their kind support and guidance. We also would like to thank our special guests, key note speakers, presenters and participants for their valuable time and support. At this time, it is necessary to extend our special thanks to the staff/Faculty of Agriculture and the organizing team of the ICDA-2015, in particular convener, Dr.S.Vasantharuba for his outstanding leadership. To summarize, we are sincerely appreciative to all who have supported us and contributed to this workshop in one way or the other. This event wouldn't have been possible without them.

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

Ms.Vanathy Kandeepan
Secretary/ ICDA 2015

Ms.Anushiya Sireeranhan
Secretary/ ICDA 2015

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Plenary Address

Resource Use Efficient Crop Cultivars for Climate Resilience

Professor S. Robin

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Population growth rates globally have so outstripped the linear rate of increases in food production that the Food and Agriculture Organization of the United Nations (FAO) estimated that 70% more food (FAO 2009) must be produced over the next four decades in order to nourish adequately a human population projected to exceed 9 billion by the year 2050. The odds for attaining such an unprecedented increase, which would require the raising of the historically linear increases in annual food production by 37% (Tester and Lang ridge 2010), is significantly burdened by the consequences of climate change and variations on crop production systems (Beddington *et al.*, 2011).

With the dwindling agricultural land and water resources, the sought-after increases will therefore be attained mainly through the enhancement of crop productivity under eco-efficient crop production systems. High input agriculture involving non-renewable water extraction, scrupulous application of fossil fertilizers and intensive cropping is often levied with the causes enhancing global warming. There is an urgent need to develop integrated and sustainable approaches that will significantly increase both production per unit land area and improve the resource use efficiency of crops. Definite and sustainable increases in production have to come through new varieties which are able to produce satisfactorily on marginal land that are presently not considered appropriate for arable crops. New crop production technologies and varieties are deemed necessary to increase both yield and resource use efficiency on the best land. 'Smart' crop varieties that yield more with fewer

inputs will be pivotal to success. Plant breeding must be re-oriented in order to generate these 'smart' crop varieties (Mba *et al.*, 2012).

Some of the promising genomic tools and strategies are presently in the breeders' kit that can enhance time and cost effectiveness of breeding for climate-resilient major cereal crops. Employment of modern breeding strategies such as high throughput genotyping, whole-genome re-sequencing, precise phenotyping, and genomics-assisted breeding including genome-wide association studies, breeder-ready marker development, rapid-cycle genomic selection, marker-assisted recurrent selection, and crop modeling (Chittaranjan, 2013) are here to revolutionize the art of crop breeding. Genome engineering for targeted mutagenesis by editing genes serves as a potential strategy for generating elite cultivars of crop plants with durable climate resilience. Designer crops have to be developed with enhanced efficiency in the use of radiation energy, nutrients, and water; they also have to fit the system of conservation agriculture including zero tillage. (Kole *et al*., 2015).

Major yield increases may come about as varieties are developed which are able to exploit in-hospitable environments, thus increasing agricultural land use. In the best agricultural land, economic demand will always favour high yields and production; however, in addition, efficient use of resources in agricultural and consumer systems will be a priority (Martin *et al.*, 2010).

Increasing photosynthesis has the potential to increase crop yields. Although wheat yields have increased, this was not due to an increase in total biomass but rather due to an increase in harvest index (i.e. the proportion of the total biomass devoted to grain at harvest) and also due to improvements in agronomic practice including the use of fertilizers, herbicides and pesticides. The harvest index for wheat is thought to be approaching a ceiling and any further increase in yield will need to involve an increase in total biomass and therefore more photosynthesis (Sage and Sage, 2009). CO_2 enrichment experiments clearly demonstrate that provided that other constraints do not become limiting, increasing photosynthesis will increase yields (Ainsworth,

2005). Thus, photosynthesis is a major target for improving crop productivity both via conventional breeding and biotechnology (Richards, 2000; Dunwell, 2000).

Plant growth, including canopy production for efficient photosynthesis is dependent on adequate nutrition, and optimized fertilizer inputs, which are essential components of efficient crop production. The efficient use of both N and P is of particular concern for food security and sustainable production, and are key targets for crop breeding programmes which have previously often been ignored. Increasing yield without additional inputs of mineral fertilizers is by definition an improvement in nutrient use efficiency. However, yields must be sustainable to provide food security. In many cropping systems, inputs are minimal and yields are sustainable while production is low, a situation which may be appropriate given other physical limitations to production. In any agricultural system, the inefficient use of fertilizers, and particularly nitrogen, contributes to the carbon footprint of agriculture and therefore potentially to climate change. On the other hand, climate change impacts on crop development and growth with concomitant implications for timing and amounts of fertilizers (Hawkesford, 2010). It has been estimated that for grain crops, globally, N use efficiency may be as low as 33% (Raun and Johnson, 1999). While not all agricultural systems are subject to such losses, worldwide this represents a huge waste of resources and a threat to food security due to the increased costs of fertilizer production and/or losses of non-renewable resources, which is specifically the case for phosphate.

Nutrient use efficiency may be defined in many ways; however, essentially there is a requirement for maximizing outputs and not wasting inputs. In the case of many nutrients, the overall trait of efficiency is divided into two major components: efficient uptake (thus minimizing fertilizer losses) and effective utilization of the nutrients taken up to produce useful croppable biomass. In addition, post-harvest processing and utilization will have a big contribution to the whole system nutrient budget. However, for the crop,

uptake efficiency is primarily a set of root characteristics, principally architectural (density and depth of roots), but also related to function (uptake and translocation of resources). Prolific shallow roots may be required to capture applied fertilizer, particularly immobile species such as phosphate, and deeper roots are likely to be important for accessing water and deeper N reserves. The second key trait involving efficient production of useable biomass will depend on canopy function (photosynthesis), architecture, longevity and efficient remobilization of nutrient from discarded/non-harvested material to the croppable biomass. It is necessary to combine genetic improvement with resource management: major inefficiencies for N or P use are not uniformly distributed geographically or across farming systems or crops. Traditional crop varieties were possessed with effective root biome, which harboured beneficial rhizotrophs capable of fixing and favouring uptake of nutrients from the soil. Due to the selection based on yield alone, and because nutrient use efficiency is a complex trait, optimal performance in the sub traits which include efficient capture may not have been combined in current elite varieties, and essential alleles may have even been lost from modern variety gene pools.

In addition to traditional breeding methods and the selection of varieties for nutrient use efficiency, whether for yield and high nutrient use efficiency under intensive conditions, or for effective nutrient scavenging under nutrient-limited conditions, a complementary approach is the targeted identification of underpinning processes contributing to nutrient use efficiency, for example, and the constituent genes controlling these processes. These genes would be involved in nutrient acquisition as well as efficient utilisation of the nutrients taken up, including appropriate partitioning between harvested/non-harvested plant parts. A number of approaches are being followed, including traditional quantitative trait loci (QTL) analysis (Habash *et al*., 2007) and mapping of underpinning genes as well as target gene manipulation, with candidates identified either through biochemical or genetic

approaches. Traits to optimize nutrient use in wheat were identified as root density to aid capture, stem storage, low leaf N, efficient remobilization to grain and customized grain attributes (protein *v.* carbohydrate) suitable for specific markets (Foulkes, 2009).

Many current environments experience high temperatures that reduce crop yield, and projected increases in temperature could reduce grain or fruit yield by about 10 % per 1 degree Celsius increase in temperature. Yet, relatively little effort has been devoted to breeding for heat tolerance. Rise in temperature although has helped the temperate countries to register high productivity in the field crops, in tropical countries it might affect the production drastically. However, for a few crop species like rice, heat resistant cultivars have been bred by conventional hybridization and selection for heat tolerance during reproductive development. The successes that have been achieved are described and provide blueprints, whereby heat-resistant cultivars could be bred for many annual crop species (Manjit and Banga, 2013). Some of the component traits like early morning flowering (EMF) and shortened grain filling duration (GFD) are exploited by the rice breeders to develop heat resistant cultivars.

Carbon sequestration in plants has been proposed as a possible moderator or solution to the rising levels of atmospheric carbon dioxide (CO2) threatening to alter global temperature and climate. The contribution of mycorrhizal and other soil community-level interactions such as azolla is an important reminder that healthy soils are required for the uptake of nutrients needed for efficient carbon sequestration.

Climate Resilient Agriculture (CRA) means the incorporation of adaptation, mitigation and other practices in agriculture which increases the capacity of the system to respond to various climate related disturbances by resisting damage and recovering quickly. Such perturbations and disturbances can include events such as drought, flooding, heat/cold wave, erratic rainfall pattern, long dry spells, insect or pest population explosions and other

perceived threats caused by changing climate. In short it is the ability of the system to bounce back. Climate resilient agriculture includes an in-built property in the system for the recognition of a threat that needs to be responded to, and also the degree of effectiveness of the response. CRA will essentially involve judicious and improved management of natural resources viz., land, water, soil and genetic resources through adoption of best practices (Parvatha Reddy, 2014).

Enhancing the resilience of agriculture to cope with climate variability and climate change is imperative to the livelihood security of millions of small and marginal farmers in the country. Devising appropriate adaptation strategies will enable farmers to cope with various climate risks, promote efficient use of natural resources to bring sustainability to farm production and stability to their incomes.

Some of the smart practices and technologies recommended by National (Indian) Initiative on Climate Resilient Agriculture (NICRA) cited by Prasad *et al*, (2014) are land shaping for rainwater harvesting, utilization and integration of farm enterprises, establishment of community paddy nursery, direct seeded rice in un-puddled field to cope with water shortages, drum seeding technique, short duration and drought tolerant varieties, short duration finger millet varieties for delayed monsoon, flood tolerant varieties and zero tillage.

Climate change will likely lead to an increased level of interdependence on plant genetic resources further highlighting the need for collaborative efforts and pragmatic approaches to provide access and share the benefits of such resources on a global level. The introduction of new technologies is not merely a technical issue but involves social, economic, and political aspects as well. The success in introducing new technologies meant to address climate change depends on effective interactions among scientists in these areas, but will also require input from stakeholders in civil society.

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Key Note speeches

What's next? Trends shaping the future of the commercial horticulture – science and innovation.

Mr.E.Arne Svinningen,

Chairman/Managing Director, Green Farms Pvt Ltd, Marawila, Sri Lanka

The first two students from your faculty came to Green Farms in 1994 to do their final year research of the BSc degree program. In all at Green Farms we have had more than 100 students from all the Universities in Sri Lanka – more than 50% from Jaffna University !

After been married for 25 years you start to know and accept each other – strength and weakness - and learn to have common goals. The same in the relation between the Faculty of Agriculture of University of Jaffna and Green Farms – friendship and love for common interest to protect our environment and develop a sustainable agriculture without use of chemicals - have been common goals.

I'll not take too much time to deal with the history but we need to learn from experience and select the right path for future. In my presentation I'll deal with two key groups of people; One is "Farmers' and the other is 'Consumers'. The farmer knows how to grow his crop but how much does he know about today's consumers ?. The key words in the discussion are ; Logistic, Communication, Convenience and Niche markets.

The World market for horticulture crops is mainly fruits, vegetable and floriculture. In value terms; Fruits- 50%, Vegetables -25% and Floriculture - 25%. The annual increase is 5 – 10%. Let me first draw your attention the following facts;

Out of the total production of fruits and vegetable in Sri Lanka only 60% reach the end consumer. The total production has increased but the loss today in

percent is the same as for 25 years ago. 40% loss means a lot of money. Who pay for these losses? Nobody else other than the farmers and the consumers have to face the bill.

What can we do to improve post harvesting and logistic – cold chain, packing and handling? Subsidies for fertilizer don't solve the problems. Of the countries I've visited in the World, Sri Lanka is the only I've not found a type of co-operative of farmers. We need to create new models to be able to introduce the latest technology and we can perhaps gain experience from Japan and Israel.

I'm born on a small farm in Norway and after the Second World War we were left with nothing – ten neighbors came together and formed "machine ring" – this still existing and we all gain the benefit of latest technology. Let me draw your attention to another fact – export of fruits and vegetable.

Only a hand full of exporters are engaged and invested in production or deal direct with the farmers. Approximately 80% is bought from the Colombo market, which means the best quality is gone.

Banana production:

In Sri Lanka we have registered 5 out of 6 known banana virus. 15 years ago I wrote a comprehensive paper about how other countries have solved the problems and how we could solve our problems. Our annual yield is also today only 10 tons per hectare. Starter material has to come from virus free tissue culture. A challenge is also to establish a banana pure factory. Today banana pure is one of the most used ingredient in baking and readymade food.

Example from WEST:

10 to 15 years ago the harvest were brought into grading and packing halls before placed in cooling rooms with specific temperature and humidity. Today

the grading and packing take place in the field and the produce go direct to the cool rooms.

Floriculture:

Production and export of plants started in 1979 and in the beginning of eighties cut flower and later cut foliage. In 1991, Sri Lanka was number 6 as exporters of plants to Europe, (Europe is 65% of the World market). 80% of the export was plants and 20% cut flowers and cut foliage. Today 80% of the export is cut foliage. Of the World market cut flowers are 60% - plants + 35% and cut foliage less than 5%. Cut foliage is the most price sensitive market and least sustainable. We need to be more innovative and add the value here to finished plants. One unskilled worker in Europe is paid Euro 15, -- per hour which means + RS 40, -- per minute. In 1980 only 3% of floriculture produce was sold through super market – today + 70%.

New challenges for science and innovation.

Biological control of pest and diseases:

Today we are harvesting from more than 25 years of work to control pest and diseases by biological, botanical and also experience to use predators. IPM is a word used for more than 30 years without any meaning or results. We prefer to call it **'ICM -integrated crop management' –** because when we are dealing with natural component it's a concept.

A few years back I had the pleasure to be invited to one of the biggest multinational Companies in the World. I spent one day with the head of their biological division – a unit build over more than 100 Acers. Very impressive units with the latest technology but at the end of the day I said "I feel we have different interests because you look for the active ingredients such as you can synthesize our products." His reply was "for sure we have all the facilities and this is the way we earn money."

Over the past several years, biological products for the control of pest and disease have attracted increasing interest. In Green farms there is a growing demand for alternatives to chemical control because of stricter regulation regarding pesticide residues. Presently, we have succeeded to produce Organic fertilizer (vermi-compost/mushroom compost), Bio-control agents (*Trichoderma* spp, *Nomuraea rileyi* and *Metarhizium anisopliae*), Botanical pesticides (Neem seed extract, Neem oil, Garlic extract, *Adhathoda vasica* leaf/,flower/bark -extract) for controlling plant pests and plant diseases . *Trichoderma* spp (*viride, harzianum* and *asperellum*) have been extensively using as soil treatment, root protection, incorporated in potting media and direct spray of spore suspensions on to fugal lesions. Spray applications of *Trichoderma* spp spore suspensions for control of foliar phase of the disease has provided excellent results in the field. Field applications showed that *Trichoderma* spp effectively inhibited the development of plant parasitic nematodes *Meloidogyne incognita*. The use of *Trichoderma* species as a potential bio-agent had claimed not only to reduce the incidence of plant disease but also to sustain the growth and vigor of the plants to most fit for exporting.

We have now achieved to reduce our consumption of chemicals further to come under 5 % of what we used 10 years ago and with earth worm technology and special fungi treatment of fibre dust we have reduced our use of inorganic fertilizer to less than 25 %. New entomopathogenic fungi have been developed and we have identified mycorrhizae for our palms but more work to be done and not at least to test different combinations with other beneficial fungi.

Mother Nature has existed for million of years and don't need you and me - but we need the nature!!!

Agricultural water management for sustainable environment

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Sensible management of soil and water resources is important for long term sustainability of the agriculture as well as the environment so that it can be used by the future generations. However, poor soil and water management practices at farm level could lead to impairment of water resources and eventually cause environmental hazards such as hypoxia in Gulf of Mexico and eutrophication of Lake Winnipeg. Mismanagement practices including inefficient irrigation, excessive irrigation, improper fertilizer application (amount and timing), and uncontrolled drainage are some of the reasons for water quality degradation. Agricultural non-point source (NPS) pollution is a growing concern throughout the world which impairs the water quality of groundwater, rivers, lakes and coastal ecosystem. Major NPS pollutants that are detrimental to water quality include sediments, nutrients, organic substances, pathogens, and pesticides. This could affect safe drinking water supply, recreation, and other livelihood activates of the communities which are dependent on those bodies of water. Incorporating best management practices (BMPs) in agriculture is proven method to minimize the environmental hazards by conserving soil and water without compromising profitability. Vegetated filter strips, wetlands, riparian buffers, shelter belts, nutrient management planning, grass water ways are some examples of BMPs which can be used at farm level. Water conservation can be carried through precision agriculture, use of GIS and remote sensing, use of efficient irrigation methods, and other water conservation techniques. The effectiveness of the BMPs may vary depending on location, climate, soil type, and crops grown however through research and development, suitable BMPs can be designed. Adaptation of BMPs could be increased through cost sharing, technical assistance and economic incentives to farmers, advocacy and policy changes.

Keywords: Non-point source pollution (NPS), Best management practices (BMP), Agricultural water management

Agricultural Extension: An Important Component of Agricultural Knowledge and Information System in the Food Crop Sector of Sri Lanka

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Introduction

Agriculture continues to play a dominant role in the Sri Lankan economy. Even though its contribution to the Gross Domestic Product (GDP) has declined substantially during the past four decades (from approximately 29 per cent in 1970 to 10.8 per cent in 2013), it still remains the most important source of employment for the Sri Lankan workforce. Approximately 38 per cent of the total labour force was engaged in agriculture in 2013 (Central Bank, 2014). The country's agricultural policy continued to focus on increasing domestic food production to ensure food security, reducing import expenditure on food and promoting export agricultural exports. The major role of the domestic food crop sector is to provide a growing strength to the Sri Lankan economy by ensuring food security while improving the livelihoods of farmers engaged in domestic food production.

Agricultural Knowledge and Information System

Knowledge has been defined as a set of concepts, meanings, skills and routines acquired actively over time by individuals or groups. Some knowledge is acquired through scientific research; other knowledge is developed through daily practice and testing by generations of people. It is the outcome of information processing, storage and retrieval going on in the neuro-physiological system. Information constitutes data organized and represented in such a way so as to acquire a certain meaning for future action of receivers (Engel, 1987). Knowledge stored in the neuro-physiological system is

transformed (encoded), when needed, into information and transferred. The receiver will transform (decode) the information into knowledge.

All systems are composed fundamentally of networks of connected entities (Havelock, 1986). Roling (1988) has defined the knowledge system as a set of institutions, organizations, and/or persons, and their linkages and interactions, engaged in the generation, transformation, transmission, storage, retrieval, consolidation, dissemination, diffusion and utilization of knowledge and information with the deliberate purpose of working synergically to support decision making, solve problems and/or introduce innovation in a given sector, branch, discipline or other domain. Engel (1987) describes agricultural knowledge system as the combination of individuals, groups, organizations and institutions that use agricultural knowledge in a certain delimited area. It includes, among others, political authorities, planners, agricultural researchers, agricultural extension workers, non-government organizations, farmer organizations, farmer training centres and the media. At the same time, according to Kaimowitz (1988), agricultural technology system "consists of all the individuals, groups, organizations and institutions engaged in developing and delivering new or existing technology".

The research – extension – user linkages play a substantial role in the agricultural knowledge system, as they represent the connections between the components. Thus the three major components namely research, extension and user have been considered as separate, but inter-related subsystems constituting the agricultural knowledge system. Nagel (1980) identified the following six basic functions in effective knowledge / information / technology dissemination process: identification of the needs of the users, generation of innovative knowledge, its operationalization, dissemination, utilization and evaluation. The traditional view was that the research sub-system was responsible for the development of agricultural knowledge and the extension sub-system was responsible for transmitting this knowledge to the users who

were considered passive acceptors of the same. Today, however, all the actors in the system are regarded as engaged in all the basic processes. Not only farmers utilize the knowledge generated by research, but also, research utilizes farmers' knowledge. Not only researchers conduct research, farmers too engage in experimentation.

Agricultural Research

Agricultural research in Sri Lanka is carried out by many institutions coming under different ministries. The Sri Lanka Council for Agricultural Research Policy (CARP) was established in 1987 by an Act of Parliament primarily to coordinate agricultural research dispersed in the different ministries. The Department of Agriculture(DoA) established in 1912, is the largest organization conducting research in food crops in the country. The mandated crops of the Department include rice, other field crops and horticultural crops such as vegetables, roots and tubers, and fruits. The Research Division of the Department is structured with the following: a) six Regional Agricultural Research and Development Centres located in the major agro-ecological regions; b) three national centres with research facilities for specific activities namely Farm Mechanization Research Centre, Natural Resource Management Centre and Plant Genetic Resources Centre; and c) four commodity-based research institutes viz. Horticultural Research and Development Institute, Field Crops Research and Development Institute, Rice Research and Development Institute, and Fruits Research and Development Institute. Each of these centres and institutes is organized with various research divisions.

Research-Extension Linkage

Agricultural research is of little use if the technologies developed are not adopted by the farmers. Fruitful agricultural research thus requires researchers to be oriented towards farmers and their problems so that the technologies developed by research are appropriate to the farmer / farm

technically, socially, economically and also environmentally. A two-way linkage between research, extension and farmers is, therefore, necessary; while solutions to problems are passed on to farmers by extension, farmer problems need to be fed to research.

Realizing the need for effective linkage, various attempts were made during the early days to strengthen the liaison between research and extension divisions of the DoA but with little success. The two divisions executed their programs as if they were two separate line departments without much horizontal coordination. The interactions between the two divisions were restricted to ad-hoc hurried consultations, usually seeking assistance in crisis situations such as pest outbreaks (Wijeratne, 1988). Subsequently, formal mechanisms were devised to strengthen the research-extension linkage through the following activities (Rupasinhe, 2014):

i. Provincial Technical Working group (PTWG): It provides a regular forum for research and extension staff engaged in different disciplines to interact with one another and come to an agreement with regard to sharing responsibilities for production programs to be implemented during the coming season. The Provincial Director of Agricultural Extension and Deputy Director (Research) of the Regional Research Institute act as "Co-chair" and the head of the Regional In-service Training Institute performs as the Secretary. The PTWGs meet before the commencement of each cultivation season and priorities for the on-coming seasons are agreed upon.

ii. Annual Symposium of the DoA: All senior scientists, technical officers and extension officers of DoA are invited to the symposium and are given opportunities to present their findings of research outcomes, experience gained in extension activities and results of socio-economic studies. The event has helped develop a better understanding among officers of different disciplines throughout the country.

iii. Researchers as trainers: The researchers serve as resource persons in various farmer training and training-of-trainer programs . This creates an opportunity for the extension officers to discuss their field experiences and give feedback on the technical recommendations given by the researchers, enabling all three stakeholders -- farmers, extension workers and researchers to understand one another better.

iv. Disciplinary-wise working group meetings: Research officers of a specific discipline get together before the commencement of each season. Scientists from both central and provincial research institutes contribute towards deciding research priorities. Representatives from the extension service are also invited to make their observations.

v. Involvement of research officers in the conduct of on-farm trials. However, in practice their realization was often problematic and the much-needed linkage still remains rather weak.

Importance of Agricultural Extension

The demand for food is increasing rapidly, especially in developing countries like Sri Lanka with comparatively high rates of population growth. These countries will not be able to import much of their food because they have few exports to generate funds to pay for food imports. The food production should, therefore, be increased rapidly to avoid serious shortages. This increased production has to come mainly from intensive cultivation, that is, from increased productivity of the existing cultivated lands rather than from increased land use, as in the past. This is because, little unused land is still available, and it requires comparatively more capital to bring new land into production than to increase yields.

Increasing yield per hectare implies the shift from traditional methods of production to new scientific methods that include new technological components such as new varieties, cultural practices and new farming systems. In many countries there are wide gaps between the yields that could be

obtained through the use of available production technologies and the yields obtained by the majority of farmers. This is due to the wide knowledge - practice gap. The level of adoption by farmers of the available agricultural technologies is reported to be 26 percent in Bangladesh and about 30 percent in India (Karim, 1999).

Agricultural extension agents can certainly help narrow down these gaps by helping farmers form sound opinions and to make the correct decisions with respect to the use of available resources and the adoption of improved technology in agricultural production; complex technologies especially need an in-depth educational and communication inputs. However, the impact of agricultural extension will be the greatest only in the immediate growth potential areas where the other agri-support services such as credit facilities, farm to market roads, retail outlets for farm inputs, local verification trials and markets for farm products are already developed (Mosher, 1978). Agricultural extension, of course, has an indirect role to play in developing some or all of the above services. Extension thus lies at the heart of agricultural development and a strong network of extension is a vital pre-requisite to reap a good harvest of the scientific, technological and educational advancements of a country (Kashem and Halim, 1999).

History of Agricultural Extension in the Food Crop Sector

Agricultural extension service in the food crop sector has been built-up over the years as an evolutionary process (Sivayoganathan and Wirasinghe, 1992). During the latter part of the 19th century a few Agricultural Instructors (AIs) were appointed to work directly under the Government Agents who were vested with the responsibility of increasing food production in the country. In the 1920s when the country faced severe food shortages as an aftermath of the 1st world war, the agricultural extension service was developed as a part of the DoA. Immediately after independence the government paid greater attention to rice production and a large number of village level extension workers were

recruited to gain direct contact with the farmers. Over the years the agricultural extension service expanded, and in 1963 a separate Division of Agricultural Extension was created in the DoA. The extension service, which previously concentrated on rice was expanded to include a few other crops such as chillies, onions, potatoes and vegetables.

In 1980, recognizing the need to improve the extension service, the training and visit system was introduced through the World Bank assisted Agricultural Extension and Adaptive Research Project. Under the training and visit system there was one village level agricultural extension worker (KVS) for every 750 farm families. These extension workers visited the contact farmers and the farmer groups regularly and advised them regarding the adoption of new farming techniques. Although the training and visit system had some positive results, after the termination of the World Bank project, the government was unwilling to sustain the required level of recurrent funding which was prohibitively high.

In 1989, under the 13th amendment to the constitution, the extension function of the DoA was largely devolved to the provinces. The public sector agricultural extension had further setbacks in the same year. The total cadre of 2400 *KVSs* were transferred to the Ministry of Public Administration as *Grama Niladharis* thus creating a vacuum at the field level. The transfer of these village extension workers to the Ministry of Public Administration as *Grama Niladharis* cut off the front line of the agricultural extension service resulting in a virtual collapse of the service at the village level. The AIs, who operated hitherto at the supervisory level, were thus left as the extension contact with the farmers and had to cover nearly 2500-3500 farm families. Moreover, the *Grama Niladharis* who were multi-purpose officers engaged in more pressing regulatory duties could not be used for agricultural extension work as they did not have the necessary knowledge, attitude and skills to carry out this work. This situation had even led 71 percent of the 240 vegetable farmers interviewed

to report that there was no agricultural extension service in their area (Hettige and Senanayaka, 1992).

In order to address some of the new extension challenges viz. cost effectiveness, disruption in the technical line of command, absence of grassroots level extension workers and the need for a farming systems approach, an approach based on integration of the discrete extension efforts of four line agencies namely DoA, Department of Animal Production and Health, Department of Export Agriculture and the Coconut Cultivation Board was implemented from 1993-1998 with assistance from the World Bank. This integrated agricultural extension service had shown only limited success in bringing the extension officers of the four participant line agencies to work together and establish an integrated extension system at the field level (Sivayoganathan and Kotagama, 1999). Although there were some professional advantages of the four agencies being integrated, the main driving force keeping them together was the receipt of project resources. Consequently, the integration was only temporary and the integrated approach could not be sustained after the end of the project.

The individual and group extension methods were intensified in a special program called *Yaya* (block), implemented since 2000, to increase the national rice production. The AIs selected paddy tracts having 20-25 ha of land area with 15-25 farmers, with higher productivity potential, better irrigation, and free of soil and land ownership problems. The farmer groups were provided with a package of integrated crop management practices. The DoA acted as the mediator between relevant organizations such as Fertilizer Company, Banks and other private organizations to supply all the inputs needed for the cultivation and signing forward contract agreements to assure better market facility.

At the same time, in 2002, the government took some steps to improve the extension set-up in the field to a certain extent by appointing nearly 9500 field level workers as Agricultural Research and Production Assistants who were expected to devote two days a week for extension work. Those officers were, however, incompetent to advise farmers. They were trained by the DoA to enhance their technical knowledge and to develop the necessary technical and organizational skills. These officers were expected to play an important role by helping farmers to organize themselves effectively.

In 2004, as an Information Communication Technology (ICT) initiative, for the first time in Sri Lanka "Cyber Extension" was implemented by the Audio Visual Centre of the DOA as an appropriate information exchange mechanism, which seemed affordable and convenient to rural farmers in satisfying their information needs (Wijekoon and Rizwan, 2009). The project established 45 Cyber Extension Units (CEUs) at 45 *Govijana Kendra* offices (Agrarian Service Centres) during the period 2004-2006. Interactive Multimedia based digital extension strategies were used in these units. Continuous monitoring and evaluation of digital extension mechanism were done and improvements made. After considering the rapid development of e-governance situation in Sri Lanka, Internet connections were provided to CEUs to enhance national agricultural research and extension system by improving the generation and collaborative use of agriculture knowledge and information system.

Under the ICT initiative, a Toll Free Agricultural Advisory Service with a dedicated hot line (number 1920) was also established which has become popular among the farming community and general public in Sri Lanka. Another ICT initiative of Cyber Agriculture, Wikipedia (www.govia.lk), is a participatory and interactive web tool developed for agricultural development in Sri Lanka through the participation of agricultural community members.

The *Yaya* program which was initiated in 2000 was further intensified as the Granary Area Program (GAP) in some locations with the involvement of other major stakeholders. Some of the innovative extension tools such as Cyber extension service, rice knowledge bank web site, media campaign, interactive multimedia CDs, crop clinics, picketing campaigns, and cultivation and yield competitions were also introduced and implemented to educate farmers. The outcome of these intensified extension efforts after three years was the increase of national rice yield up to 4.3 t/ha (Emitiyagoda, 2009).

Encouraged by the success of the *Yaya* program, the second phase was launched under the title *Yaya 2* with the aim of increasing the national productivity further. The main interventions included, environment friendly Good Agricultural Practices such as judicious use of agrochemicals, use of Integrated Plant Nutrition System (IPNS), Integrated Pest Management (IPM), use of mechanized farming techniques preferred by the young farmers, and increasing cropping intensity with the introduction of crop diversification to enhance the overall farm profitability. Appropriate technology packages for the main rice growing agro-ecological regions have been proposed. The extension approach has been designed to increase the frequency of contacts, use of ICT and frequent monitoring of the seasonal activities with the help of relevant stakeholders.

National Agricultural Extension Policy

The National Agricultural Extension Committee which was constituted in 1992 as a Standing Committee under the CARP under section 19(4) of the CARP Act was entrusted with the responsibility to develop a policy for agricultural extension service. Committee membership included representatives from the government departments, universities and the private sector engaged in the provision of agricultural extension service. The role of the committee as stated was to advise CARP on policy matters regarding: a) agricultural extension and training, b) organization, coordination, planning,

execution and funding of agricultural extension services, extension pilot programs and training, and c) research-extension-farmer linkages. Although the committee met a few times between 1992 and 1995 and discussed some policy issues related to agricultural extension, the support envisaged was not forthcoming from the authorities and it could not serve the purpose for which it was constituted.

Attaching the National Agricultural Extension Committee as an appendage to CARP did not seem to be a satisfactory arrangement for the efficient functioning of the former. A separate body could be established with the necessary authority to handle policy issues regarding agricultural extension. A somewhat better arrangement suggested, but not implemented, was to change the name of CARP to CAREP (Council for Agricultural Research and Extension Policy) and to have two committees on equal footing with the necessary authority and support to allocate resources and handle policy issues regarding agricultural research and agricultural extension. This would also help ensure proper research-extension linkage at the national level.

Training of Extension Staff

The extension workers require not only technical skills in agriculture but also the necessary skills in dealing with farmers. They have to undergo pre-service training, induction or orientation training, and various in-service training programs.

There is a long history in the provision of agricultural education and training in Sri Lanka with Schools of Agriculture and Practical Farm schools providing two-year diploma and one-year practical course respectively beginning early part of the 20^{th} century. The Faculties of Agriculture established in the University of Peradeniya in 1948 and subsequently in six other national universities provide undergraduate education in agriculture. The Postgraduate Institute of Agriculture established in 1975 in the University of

Peradeniya provides postgraduate education to some of the supervisory extension staff and subject matter specialists of the DoA. By early 1980s a Farm Mechanization Training Centre and eight In-service Training Institutes were established by the DoA in close proximity to the Regional Agricultural Research Centres. These training institutes provide regular in-service training to the field extension staff. In addition, the Open University offers Diploma and Bachelor's degree level courses with the objective of upgrading the agricultural knowledge and skills of agricultural extension workers.

The training of extension staff should, however, be intensified and better training facilities and support should be provided. Also, the profession of extension should be recognized in par with research and equal opportunities should be given to extension staff to pursue higher studies.

Outreach Extension Services by the Universities

Agriculture universities in India and elsewhere are engaged significantly in extension services for farming communities. In Sri Lanka, there are no such agricultural universities or services, but the faculties of Agriculture conduct some outreach programs targeting farming communities. Some of the farmer training and school children awareness programs conducted by the agriculture and allied faculties of the state universities for the surrounding farming communities on an ad-hoc basis are described below.

The Agricultural Education Unit (AEU) of the Faculty of Agriculture, University of Peradeniya organizes various training programs to farmers and rural youth in collaboration with national and international organizations. Another noteworthy extension initiative could be found in Ruhuna University. In this program called ‘Grow more mushroom to enhance food security’, different agricultural extension efforts have been implemented to uplift the living standards of the mushroom farmers, while increasing the productivity. The students following the Advanced Module of the Department of

Agricultural Extension of the University of Peradeniya conduct a series of comprehensive productivity enhancement training programs annually with the guidance of experts for a selected community as a part of their training. The Institute for Agro-Technology and Rural Sciences of Colombo University located in remote location of Hambantota district conducts diploma courses for farmers, provide tissue cultured banana plants and conduct farmer training. Also, the Open University offers some courses to individuals who intend to choose agriculture as their future career.

Non-State Sector Extension Services

According to Mahaliyanaarachchi and Bandara (2006) the structural change in agricultural extension could take two approaches: commercialization and privatization. Privatization is mainly changing the ownership of the extension service to private sector from public sector, which has been mainly funded and delivered by government agencies free of charge for decades. People in most of the developing countries have unpleasant experiences of privatization. Commercialization is not merely privatization. It does not need a change of ownership under commercialization. Ownership can be kept with the government or semi government organization, but the service is provided on a commercial basis. The strategies of commercialization include: decentralization, public cost recovery, contracting of services etc.

There is potential in Sri Lanka for a gradual introduction of a fee-levying private extension service among commercial farmers with a better ability to pay, leaving scarce government resources to serve the poor and subsistence-level groups of farmers more effectively. However, to be profitable, private sector extension services must be integrated into other commercial operations, such as the sale of farm inputs.

Since 2000, there has been a rapid growth in non-state actors providing extension alongside other farm services.

The CIC Agri-Businesses (Pvt.) Ltd. is the leading private sector organization providing agricultural advisory services. It is the leading supplier of certified quality paddy seed in the country through its own farms and a network of contract growers. In 2009, the organization had 110 extension staff that worked directly with over 20,000 farmers who produced a variety of agricultural and livestock products like seed paddy, rice, fruits, vegetables, eggs and yoghurt (De Zoysa, 2014). Baur and Company (Pvt.) Ltd., Hayleys Agriculture Holdings Ltd., Brown and Company Plc., Lankem Agro Plc., Unipower (Pvt.) Ltd. are some of the other private sector organizations providing extension support.

Furthermore, some international development organizations such as Food and Agriculture Organization (FAO), Canadian International Development Agency (CIDA), Japanese International Co-operation Agency (JICA), German International Cooperation Agency (GIZ) as well as local, national and international non-government organizations have also been engaged in agricultural extension activities in implementing their development project activities.

Research in Extension

Agricultural extension is a science – a complex social science. Findings of agricultural extension research are needed to understand the problems of technology transfer, research – extension gap, farmer attitudes towards and adoption of agricultural innovations, and other such issues. Gains and losses of farmers are not necessarily the same as perceived by the farmers themselves, the crop scientists, extension officers and policy makers. These issues are to be examined through extension research. Crop scientists, extension officers and the farming community at large can benefit from the findings of such research.

However, extension research conducted in Sri Lanka leaves much to be desired. It is largely restricted to the research studies conducted by the university staff and students both at undergraduate and post-graduate levels and some evaluation studies conducted by selected state institutions, international development agencies and non-government organizations. This kind of research should not be confined to the above organizations. The agricultural research institutes should have provision to conduct both crop and extension research. This could be achieved by opening up an extension division in the research institute. In the alternative, a research division could be established in the extension organization. Although rather difficult, the extension researchers should evaluate the extension service by examining both its effectiveness and efficiency. The necessary support and recognition should be given by the state and other funding agencies for such research.

Conclusions and Way Forward

Research activities in the food crop sector of Sri Lanka should be well focused on the needs of farmers and consumers, rather than being governed by the availability of research facilities and funds. Also, the outcome of existing research should be satisfactorily communicated to the extension service. Thus the research - extension linkage should be further strengthened.

Agricultural extension dealing with transfer of technology is the weakest subsystem in the agricultural knowledge and information system. The role of extension should not be viewed as mere transfer of technological information to farmers but as encompassing partnerships, cooperation and interdependence as its integral components resulting in improved interactions among the actors in the agricultural knowledge and information system.

Without a comprehensive agricultural extension policy, agricultural extension is unlikely to get the attention it deserves. It is, therefore, necessary to have a national level dialogue with wide participation of all stakeholders

engaged in the provision of agri-support services to farmers and develop policy guidelines to integrate agricultural extension as an effective partnership model. The state controlled largely top-down extension should be changed to a collaborative service where the state, the private sector, the non-government organizations and the international development agencies work together bringing more benefits to the rural farming community.

Agricultural extension should be duly recognized as a profession. In this context, the Sri Lanka Agricultural Extension Association (SLAEA), a professional body of agricultural extension workers, academics and managers of extension services has a major role to play.

Of the rather inadequate budgetary allocation for agricultural extension in the state institutions such as DoA, nearly 75 percent is accounted for salaries and allowances. Thus the budgetary allocation for extension should be increased and the extension workers be given the necessary incentives and program support to perform their duties effectively.

Strengthening and streamlining the extension service and forging better links between research and extension will help enhance the economic and social well-being of the farmers in the food crop sector.

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Abstracts

Performance of a climate change - resilient agronomic package for chilli (*Capsicum annuum* L.) in comparison to the existing crop management in the Northern Province of Sri Lanka

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Adapting cropping systems to the potential negative impacts of climate change by enhancing their resilience has become important especially for the farming communities in vulnerable regions like Northern Province of Sri Lanka. Increased ambient temperatures, altered rainfall patterns, declining soil fertility and changed pest/ disease dynamics are critical challenges of climate change on crop production. To address these challenges, a climate change-resilient agronomic package (adaptation package) that includes mulching to conserve soil moisture, integrated pest management for crop protection and site specific fertilizer application for efficient crop-soil nutrient management was formulated through a multi-locational, on-station field study across an increasing temperature and decreasing rainfall gradient and tested on chilli in farmer fields located in three upland cropping sites in the Northern Province of Sri Lanka. The sites were Nilavarai (N) in Jaffna District and Thiruvaiyaaru (T) and Mulankavil (M) in Kilinochchi District. The experiment consisted of two treatments as climate change-resilient agronomic package (T_1) and existing farmer practice (T_2). Existing farmer practice is characterized with heavy reliant on chemical control of pests and diseases and application of

inorganic fertilizers subsequent to decisions of farmer. The two treatments were imposed in a randomized complete block design where the selected farmers in each location were considered as blocks. Number of farmers was eight, four and three and the experimental period was end of October 2013 to early April 2014, end of January 2014 to end of June 2014 and mid-March 2014 to mid-August 2014 respectively in the sites of N, T and M. Crop biomass and green chilli yield were measured at harvest. Incidences of major diseases (i.e. chilli leaf curl complex and fungal wilt) were observed at the different phenological stages of chilli. Soil chemical properties were measured at the beginning and end of the season. The results showed key benefits in terms of growth and yield improvement, suppression of observed diseases and improvement of soil organic matter and available macro nutrients under the adaptation package. The adaptation package showed yield increases of 22.4%, 21.4% and 16.2% over the existing farmer practice at N, T and M respectively. Even though the adaptation package had a slightly greater cost, this was outweighed by a substantially greater income. Hence, this adaptation package could be recommended for adoption by the farmers to improve the yield of chilli while promoting lower water and agro-chemical use and having increased resilience to climate change.

Keywords: Adaptation package, Chilli, Climate change-resilient, Farmers, Northern Province.

Induction of peroxidase activity in tomato leaf tissues treated with two crop management systems across a temperature gradient

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Application of pesticides has been the main method of controlling plant diseases. However, there is a growing interest in developing alternative measures aiming to minimize the harmful impacts of pesticides on the environment and human health. Inducing systemic resistance against plant pathogens is one such environmentally-friendly approach of disease management. The present study was conducted to determine the impact of two crop management practices on peroxidase defense enzyme activity in tomato tissues. Tomato var. *Thilina* was cultivated under two crop management regimes, namely pesticide-based crop management system with recommended pesticide applications and an integrated pest management (IPM)-based system with less reliance on pesticides at five locations (Kilinochchi, Mahailluppallama, Kundasale, Peradeniya and Rahangala) representing a gradient in ambient temperature. Field experiments were conducted during *yala* 2013 using a factorial randomized complete block design. Peroxidase activity was quantified spectrophotometrically using apparently healthy tomato leaf tissues treated with the two regimes and grown at different locations. Findings revealed that there was no significant ($p=0.05$) difference between the two systems on the activity of peroxidase in tomato leaf tissues, indicating the equal efficiency of the IPM treatment on induction of host plant resistance as the crop protection practice relying on more applications of pesticides. The activity of peroxidase in tomato tissues significantly varied ($p<0.05$) among locations. In general, the highest peroxidase activity was recorded at Peradeniya and the lowest was reported at Kilinochchi. There was

no significant relationship between peroxidase activity of tomato tissues and the mean day temperature of the day prior to the sample collection under the two crop management systems. Effect of crop management system on the activity of peroxidase in tomato tissues was significantly influenced ($p<0.05$) by the location effect.

Keywords: Integrated pest management, Peroxidase, Temperature gradient, Tomato.

Bee Diversity and Floral Hosts in the Home Gardens of Jaffna District

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A study of the diversity of bees and floral hosts in the home gardens of Jaffna District documented fourteen species of bees in four families, Apidae, Halictidae, Anthophoridae and Megachilidae involved in pollination process of flowering plants. Majority of bees belong to the family Apidae (57.14%). Four species of social bees, *Apis. dorsata, A. cerana, A. florea* and *Trigona iridipennis* were present in the home gardens of study site. Ten species of the solitary bees were foraging on pollen and collecting nectar of a variety of flowers on home gardens. *Amegilla sp, A. cingulata, Braunsapis cupulifera, Ceratina binghami, Lasioglossum vagans, Xylocopa fenestrate, Thyreus ramosellus, Nomia iridescens, Megachile mystacea* and *Lipotriches pulchriventris* were categorized under solitary bees. The floral hosts of bees included 66 species of flowering plants in thirty four families. A total number of 1448 individual plants, Majority of the floral host plants of bees belonged to the family Fabaceae. Highest numbers of bee species were visited to the vegetable crops in home gardens. Highest bee diversity was recorded on Cucubitaceae family crops. Cucubitaceae flower of *Luffa cylindrica* was attracted the highest number (9) of bee species. Fruit crops also were received high number of bee species next to vegetable crops. *Tringona iridipennis* bee species were indentified in twenty six plant species. *Thyreus ramosellus* and *Megachile mystacea* bee species were found only in certain flowering plants. The diversity of bees appears to be determined by the availability and diversity of suitable floral hosts in the home garden.

Keywords: Bees diversity, Flowering plants, Home garden, Pollinators.

Awareness of Banned Pesticide usage among Vegetable Grower's and Health impacts in the Vavuniya District

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Pesticides kill or deter the destructive activity of the target organism and they posses' inherent toxicities that endanger the health of the farmers, consumers and the environment. The objectives of this study were to investigate the awareness of banned pesticide usage and study the health impacts caused by agrochemical in Vavuniya district. Primary data was collected from 120 randomly selected farmers among vegetable cultivators in Vavuniya district through questionnaire survey. Primary data were socio-demographic characteristics, pesticide management practices and health impacts. Secondary data were collected from RDHS (Regional Directorate of Health Service) in Vavuniya. The collected data were analyzed using the Pearson correlation test, frequency analysis and crosstabs in SPSS (Statistical Package for Social Sciences), version 16. Almost all farmers depended on synthetic pesticides for the management of pest and 58% of the farmers used moderately hazardous (Class II) pesticides. Around 51% of the farmers applied the pesticides 10-20% higher than recommended level. Sixty two percentage of the farmers used banned pesticides and which are still available in the local market. Around 60% of the farmers harvested the products within seven days from the pesticide application. Number of cancer patients increased from 2010 (177 patients) to 2013 (300 patients) in Vavuniya District. Therefore, residual effect of pesticides, over dosage of pesticide usage and poor safety measures may cause kidney disease, cancer and liver failure in this study area.

Keywords: Awareness, Banned pesticides, Farmers, Health impacts.

In-Situ and Ex-Situ Conservation of *Solanum xanthocarpum* in Jaffna District

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Solanum xanthocarpum is important medicinal plant in traditional practices. It is known by the Tamil name "Kandankathari". It means cutting phlegm from throat. It is used to treat the respiratory disorder in Indigenous medicine. The period of King *Pararasasekaram* and *Sekarasasekaram*, *S. xanthocarpum* cultivated and used in Jaffna. The books originated from Jaffna such as *Pararasasekaram* and *Sekarasasekaram* are clearly mentioned the plant of *S. xanthocarpum* in *Slogams*. At present *S. xanthocarpum* is imported from abroad. It is evident that *Solanum xanthocarpum* imported *2, 08650 Kg in 2011* from India. The land and climatic conditions are suitable to cultivate in Jaffna. The study objected to protect the naturally growing plant and cultivate to fulfill the required quantity of *S. xanthocarpum*. Study of In-situ conservation, the researcher made field visits to 15 DS areas to observe the naturally growing plant in 2013according to the field visits' records of Gunapadam branch unit of Siddha medicine .The plants are available around the Vallipuram temple, Kudathanai, Nakarkovil in Pointpedro North and Vadamaradchi East DS division. More or less amount of plants noted in Velanai, Kayts and delft DS areas. Fewer amounts of plants noted in Thenmaradchi and Vadamaradchi North West DS areas. Rare in other DS areas but occasionally noted small group of plants. Study of Ex-situ conservation, Ten Larchum of land selected for the cultivation with the permission of DS. Genuine seeds were obtained from taxonomist. Four mother plants were selected to cultivate. 150 – 250 fruits collected from each plant. Nursery beds made to grow seedlings. 27 days later 1000 seedlings transferred to standard plots. 900 plants uprooted after 6

month. Among those 300 were small and 600 were large. This was nearly 825Kg cultivated. The study shows that the collection and cultivation practice in Jaffna district is succeeded. The researcher suggested that the proper collection and cultivation practice of *Solanum xanthocarpum* will be the benefit to the shareholders and country.

Keywords: Conservation, Ex-situ, In-situ, Kandankathari, *Solanum xanthocarpum.*

Study on the removal of iron and manganese in groundwater and surface water by oxidation and micro filtration

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Water resources are becoming increasingly scarce in many areas of the world due to development, and increased demand. Groundwater is the major natural water resource in the Jaffna peninsula. One of the problems related to groundwater is the reddish colour caused by the presence of ferrous and manganese which may cause taste, odour, colour, or turbidity problems.The objectives of the study were focused on removal efficiency of iron and manganese, turbidity, color, and bacteriological parameters through oxidation and microfiltration process and consideration of low cost and suitability in domestic level. Water samples were collected with problematic locations as especially from Thenmaradchi for iron and manganese, Thirunelvely, and Pasaiyoor and Kurunagar areas pond water for coliforms and E.Coli. Preliminary test was conducted to select suitable aeration time and overnight aeration was identified based on the removal efficiency. The iron, manganese, color, turbidity, pH, electrical conductivity, alkalinity, fluoride, sulphate, total phosphate, chloride, nitrates, total coliforms and *E.Coli* were tested for raw and treated water samples. The iron removal efficiency through micro filtration alone was varied from 18% to 100% and the manganese removal efficiency was varied from 65% to 100%. Higher percentage of Mn^{2+} was removed by microfiltration compare to Fe^{2+}. But the removal efficiency for both Fe^{2+} and Mn^{2+} was 95% by oxidation and microfiltration process for surface and groundwater. The color and turbidity both reduced due the removal of iron and manganese. The bacteriological removal efficiency, total coliforms and *E.Coli* was 100%. There were no different in other water quality parameters.

Microfiltration process also reduces the nitrate nitrogen content of the groundwater. Microfiltration could be introduced for treatment of groundwater and surface water for color, turbidity, iron and manganese and bacteria removal at domestic level.

Keywords: Ground water, Iron, Manganese, Micro filtration, Oxidation, Surface water.

Determination of water quality and evaluation of the trophic state of Udukirivila reservoir, Weerakatiya, Sri Lanka

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This study was conducted to determine the basic physiochemical parameters, Water Quality Index (WQI) and Carlson's Trophic State Index (TSI) in Udukirivila reservoir, Weeraketiya, Sri Lanka. It is in a cascade system connected to Muruthawela reservoir. Catchment area consists with residences of the villagers and farm lands. Water sampling was performed four times during two months period from October 2014 to November 2014 at randomly selected seven sampling sites from the surface middle and bottom of the water column at each site. Average water depth of the sites were taken as an indicator of the inflow and observed as 1.44±0.82m, 1.32±0.76m, 1.79±0.68m and 1.71±0.67m during the four occasions respectively. Though bottom temperature, BOD_3, Chlorophyll-a, TSS, pH, surface and bottom conductivity, nitrate and phosphate didn't indicate significant variation among seven sampling sites except surface temperature, surface and bottom DO. Most of the parameters showed significant variation among four sampling occasions except surface temperature, BOD_3, bottom conductivity, surface DO and surface nitrate. The values of WQI and TSI were not significantly different among the sites. However, WQI and TSI values varied significantly among the four sampling occasions. The WQI for occasion 1 (45±8) and occasion 3 (29±10) explained bad water quality and occasion 2 (64±6) and occasion 4 (60±15) showed medium water quality. The TSI values indicated eutrophic conditions in the reservoir when considering secchi depth and total phosphorus concentration in water. The eutrophic condition is visible in the google maps of recent years as the large coverage of aquatic macrophytes (nearly 1/3 of the

surface area). The temporal variation of the water quality parameters was clearly identified in the study and it revealed that water quality of the reservoir is badly affected by the runoff from the catchment area. The water from the reservoir cannot be recommended to use as a source for drinking water treatment via conventional treatment.

Keywords: Reservoir, Trophic State Index, Water Quality Index.

Impact of alternative wetting and drying on the soil surface organic matter in a lowland paddy field

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Ponded water in lowland paddy cultivation has a role on soil biomass accumulation, decomposition, and nutrient availability. However, alternative wetting and drying (AWD) is a common phenomenon under minor irrigation systems due to scarcity of water. The AWD process may have an effect on the soil organic matter (SOM). Therefore, the effect of several cycles of varying length of AWD conditions on SOM content at the soil surface was investigated using Lysimeters for a period of 98 days. The experiment design was factorial complete randomized design with 4 treatments; *i.e.*4 days dry spell (T1), 12 days dry spell (T2), 20 days dry spell (T3) and 4 days dry spell with paddy (T4). Soil samples from the surface were collected at 14 days interval and the SOM contents were measured. Results show significant differences among the treatment combinations. The accumulation of SOM after AWD water management practices is higher for T1 followed byT2, T3 and T4. The surface SOM content has reduced by 19%, 53%, 86% and 49% of the initial SOM content for T1, T2, T3 and T4, respectively. Shorter dry spells enhance the organic matter accumulation compared to longer dry spells by creating anaerobic condition. On the other hand, organic matter degradation is higher in longer dry spells aerobic condition. This finding may help to take decisions on correct water management practices to optimize organic matter dynamics in lowland paddy fields.

Keywords: AWD, Decomposition, Low land paddy, SOM, Water management.

Biochar as a bio amendment to reduce heavy metals translocation into Maize

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Heavy metal contaminated soil is rich in Pb and Cu in extreme concentrations, generate an unfavourable surroundings for agriculture and human health through phyto-accumulation. This study was conducted to assess the possibility of particular bio-amendment, Biochar (BC) on the reduction of bioavailable Pb and Cu in such contaminated soil. Biochar produced by *Gliricidiasepium* (BC700), at a same time, it is a waste from Dendro power plant was used to evaluate its ability to be used in soil remediation. A pot experiment was conducted with Maize (*Zea mays)* by adding BC700 at three different percentages, 1.0, 2.5 and 5.0% (w/w). Soil that was taken from shooting range area of diyadalawa, without any amendments served as a control. Experiment was arranged in a complete randomized design with three replicates. Translocation rate of heavy metals into crop were determined in maize plants. Sequential extraction was conducted to determine the bioavailability and other phases of heavy metals in soil. Sequential extraction procedure was used to measure the metal concentration in soil and the total, and exchangeable concentrations of Pb were 20843, 2058 and Cu were 1861, 102 mg/kg respectively. After sixth week, maize plants were harvested and analysed followed by digestion with con.HNO_3. The most significant immobilization ($p<0.05$) was indicated by treatment 5% BC700 for Pb and Cu with 49% and 84% respectively than the control. The results suggested that the addition of 5% BC which is a waste by-product of the bioenergy industry has the capability of immobilizing heavy metals and thus reducing the phyto-toxicity in shooting range soil. Metal translocation towards plant was decreased with increasing application rate of amendments. Determination of

Plant factor (PF) and Translocation factor (TF) indicated that PF was greater than TF in maize. Heavy metal tolerant plant with high PF and low TF could be used for phytostabilization of contaminated site. There by maize could be considered as a potential phytostabilizer.

Keywords: Biochar, Dendro, Phytostabilizer, Translocation.

Inter Linkages among Agriculture, Manufacturing and Service Sectors: Empirical Evidence from Sri Lanka's Provincial Economies

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This study examines the relationships among agriculture, manufacturing and service sectors of Sri Lanka's provinces. Annual data from 2000 to 2013 for nine provinces of Sri Lanka were used to develop a Panel Vector Error Correction Model for this study. The results of this study show that there is a positive relationship between the agricultural sector and manufacturing sector. The impact of agricultural growth on manufacturing growth is about three times of the impact of manufacturing growth on agricultural growth. The negative relationship between the agricultural sector and service sector means that these two sectors competes each other for labor and capital goods. Manufacturing and service sector contribute each other for their growth. These findings would help policy makers in central government and local governments of all provinces formulate the sound policies to accelerate the economic development in all provinces.

Keywords: Economic Growth, Panel Vector Error Correction Model, Regional Economics.

Economic status of rural households with rain water harvesting systems (A case study in Monaragala District)

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Water scarcity is one of the major problems particularly for the rural households in the dry zone of Sri Lanka. It is believed that Rain Water Harvesting (RWH) may be a solution for this problem. As a result the rural households were provided the RWH structures to collect and store the rain water. The objective of this study was to assess the economic benefit of rain water harvesting. Questionnaire survey was conducted among randomly selected forty five rural households at Siripuragama GN division in Monaragala district during September to December, 2014. The data of time taken for water collection during non-rainy season, usage of Rain water harvesting system (RWHS), quantity of harvested rain water and the income earned by cultivating crops using Rain water harvesting were collected from the respondents. The results revealed that the women saved 26 man days whereas the men 16 man days and the children saved 70 hours per annum by using RWHS. Further an income earned by cultivating crops using harvested rain water and the reduction in the charges for the electricity due to rain water harvesting were assessed and considered to be an additional income for the households due to RWH. Well water consumers who had RWHS saved SLRs. 30505 (US$ 227) while non 'Samurdhi' beneficiaries of pipe born water consumers saved the SLRs.13046 (US$ 97) and 'Samurdhi' beneficiaries of pipe born water consumers saved SLRs.12341 (US$ 92) per annum. Installation of RWHS not only improve the economic status of the rural households but also conserve the water resource, hence it could be a win solution to the society and the environment.

Key words: Economic return, Economic valuation, Rain water harvesting, Rural household.

Yield and Economics of Other Field Crops in Rain-fed upland cultivation in the Jaffna Peninsula of Dry Zone of Sri Lanka

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The study was done to evaluate six common Other Field Crops (OFC) that belong to three major crop groups, grain legumes, coarse grains and oil crops cultivated as Marginal uplands under fully rain-fed conditions for three consecutive *Maha* seasons for their agronomic and economic performance at the agricultural Research Station, Thirunelvely. During first raining the land was ploughed and harrowed by four wheel tractor to ensure good weed control suitable for planting. The every variety of seeds was row sowed as rain fed Marginal land during October to November. Rainfall received from October to February (crop growing period) in *Maha*2006/07 of 751 mm, Maha 07/08 of 916.5 mm and *Maha* 08/09 of 1246.8 mm were adequate to produce satisfactory yield in all crops. The yield ranges of the crops were 850-1000 kg/ha in blackgram (*Vigna mungo*) ,350-1050 kg /ha in green gram(*Vigna radiata*),350-800 kg/ha in cowpea(*Vigna unquiculata*) ,450-700 kg/ha in finger millet(*Eleusine coracana),*1500-2000kg/ha in maize (*Zea mays)*and 1015 kg/ha in groundnut(*Arachis hypogaea*). Ground nut gave the highest net return (Rs.78500/ha) followed by, black gram (Rs.66666/ha) maize (Rs.62500/ha) and green gram (Rs. 39000/ha), including family labour. However in *Maha* season cultivation of cowpea and finger millet was not profitable. It can be concluded that green gram black gram, maize and ground nut are suitable crops for marginal rain-fed upland in dry zone of Sri Lanka.

Keywords: Dry Zone, Grain legume, Marginal, Rain-fed, Upland.

Role of Mass Media in the Decision of the Consumer Desire to go for a Sustainable Fresh Water Alternative: A Case Study Conducted Within Jaffna Municipal Limit

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An urgency has developed over the last few decades in the safety and purity and the extent of freshness of ground water which apparently is the only source of drinking water in the peninsula. This ironically is due to the indifference, negligence and the carelessness of human activity. To check this state of affairs attempts are made to rein matters considered by many as too few too late. To clear the minds of the public of this trend of thought manipulation of the Mass media is essential. Rain water collection and preservation for protracted long term use is not new to the dry zone of Sri Lanka. Yet, of recent origin, water collected using traditional methods cannot be kept free of pollutants due to the water contact with the earth. Since the source of all pollutants is the earth as it is now, attempts are made to collect, protect and preserve rain water as best as possible. The answer is rain water harvesting systems. Viable and sustainable solution to insufficient supply of freshwater could be the rain water harvesting systems. The concepts though is lacking expression here in the peninsula is widely seen all over the world. However the hesitation, reluctance and the traditional suspicion of the body polity have to be engaged and addressed. For this purpose the Mass media could be harnessed. Mass media of all variety are likely to be important for informing better investment decisions on infrastructure. The question is how best these different sources could be employed to disseminate, technical installation and health information through the electronic and printed media and how and to what variant degree people are influenced through the media. This is the question which is addressed in the research conducted as to ascertain what socio economic factors influence the decision making trend of the people at large and how the media exposure

of relevant factors affect the individual's decision. For this reason all available media material were compiled and a media exposure index was composed. The city of Jaffna was selected for this purpose and around 380 respondents were picked randomly but corresponding to the population of the relevant divisional secretarial division. A stratified purposive random sampling technique was used to pick the samples. To this end the data were collected on current water needs, health concern and household socio economic characteristics. The data were collected through three formats. They being open ended, open ended with prequalifying statements, and dichotomous choice. The collected data were analyzed within the frame work of Probit Regression model. The model was found to be significant at 1% α level. The results revealed that household desire to go for suitable fresh water alternative depends on media exposure index, household size, educational level of the household head, income of the household, and real estate extent. These factors again influenced positively and were statistically significant at 1%, 1%, 5%, 10% and 10% α level respectively. The mass media exposure index being the dependent variable in the model, it was found to be highly (1%) significant. Thus it is suggested that all up to date information on the relevant field be disseminated through the available media so that continuous and sustained information is made available to the community.

This implies that the use of available media of all kind and types, to the maximum, to explain the level of effects of water pollution and the consequent health hazards generated in the peninsula, create awareness of the impending danger to residents clearly. This results in the decision of these people seeking a sustainable and durable solution to the emergency thus driving them towards an alternate solution like rain water harvesting systems. So that being informed, they become informative and in effect the civil society transforms slowly, steadily, gradually going through a paradigm shift into a more efficient and healthy one.

Keywords: Ground water pollution, Mass media exposure index, Probit regression model, Jaffna.

Determination of antifungal activity of *A.vera* leaf powder extracts against banana pseudostem rot fungi, *Marasmiellus* spp.

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Being an important medicinal plant, *Aloe vera* is important in industrial perspective as well as traditional usage. The antifungal activity of *A.vera* leaf powder extracts was assessed against banana pseudostem rot fungi, *Marasmiellus* spp. Leaf powder with acetone and ethanol extracts of 20, 200, 400, 1000 and 2000 µl were administered to assess the inhibition of colony growth of *Marasmiellus* spp. The experiment was conducted using completely randomized design. By using *A.vera* acetone extract, in first day after inoculation, inhibition percentage was higher (74.53%) in 2000 µl and the lowest percentage (23.53%) of inhibition was obtained in 20 µl of extract. All treatments were significantly differed each other. The same highest and lowest percentage of inhibition was obtained in second, third and fourth day after inoculation also. In *A.vera* ethanol extract, the highest (100%) inhibition was observed in 1000 µl and 2000 µl extracts. The lowest inhibition was recorded (2.26%) in 20 µl of *A.vera* ethanol extract. There was no significant difference between 1000 and 2000 µl extracts. Among the 1000 and 2000 µl leaf extracts, ethanol extract had highest inhibition percentage than *A.vera* acetone extract. These findings are useful to prepare the extracts of *A.vera* leaf powder for the management of *Marasmiellus* spp.

Keywords: *Aloe vera*, Antifungal activity, Banana pseudostem rot, Colony inhibition, *Marasmiellus* spp.

Production of bio agent, *Trichoderma viride* using liquid wastes and other substrates

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In ecofriendly agriculture, *Trichoderma* species is promising bio control agent for various plant pathogens. It can be multiplied in solid and liquid media but liquid fermentation has yields high reproductive capacity and it is more convenient than solid state fermentation system. High cost for substrate, inadequate storage methods are major problems in small scale level production. Therefore this study was carried out to screen out suitable liquid wastes and other liquid media as suitable substrates for small scale production of *Trichoderma viride*. Locally available house hold and industrial liquid waste such as Black gram soaked water, Coconut water, Rice mill effluent from the red pericarp variety (At 353), 5% Distillery spent wash and other liquid substrates like 1% palmyrah jaggery solution, 5% palmyrah Toddy and 1% palmyrah fruit pulp extract, Cow urine 10%, *Gliricidia sepium* and 10% *Thespesia populnea* leaves, were Individually investigated. Among these substrates higher growth and sporulation of *T. viride* was recorded in black gram soaked water ($35.9x10^7$spores/ml), followed by 1% Jaggery solution ($30.0x10^7$spores/ml), Coconut water ($28.8x10^7$spores /ml), Rice Mill Effluent ($28.7 x10^7$spores/ml) and Palmyrah fruit pulp extract ($27.1x10^7$spores/ml) after 14 days of incubation in dark room at ambient temperature (30 ± 2^0C) . Present study reveals that locally available liquid substrates are potential source for liquid fermentation of *T. viride*.

Keywords: Black gram soaked water, Coconut water, Liquid wastes, Small scale multiplication, *Trichoderma viride.*

Effect of parboiling methods on milling yield and soaking time of two Sri Lankan rice varieties

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Parboiling is one of the popular rice processing methods in Sri Lanka where rice is the staple diet of Sri Lankan consuming around 90% of parboiled rice. Two Sri Lankan rice varieties with short white pericarp (Bg360) and medium red pericarp (Bg 406) were used for this study. Paddy & brown rice of used varieties with the initial moisture content of 13.6±0.1% (wb) were parboiled in four different methods; traditional parboiling (TP), pressure parboiling (PP), central food technological research institute parboiling (CFTRIP) and dehusked rice parboiling (DRP). The moisture content was measured in fixed time intervals during soaking, at the end of steaming and drying. Samples were dried before milling to a final moisture content of 13±1% (wb).In milling yield analysis, percentage of brown rice, hull, total milled rice, head rice and degree of milling were estimated to unit of rough rice and compared among various method of parboiled rice and non-parboiled rice (NPR).A factor factorial experiment was carried out to determine the soaking time and milling yield considering the grain type and parboiling method. Short grain rice variety required 25% to 50% less soaking time compared to medium grain. Optimum soaking duration for different parboiling methods were varied from 25 minutes to 24 hours for Bg360 and 45 minutes to 48 hours for Bg 406.The main effect of both methods of parboiling and rice variety and interaction effect were significant ($p<0.05$) for both headrice yield (HRY) and optimum soaking time. HRY was lowest for NPR compared to parboiled rice in both varieties and HRY was greater in NPR of Bg360 variety (50.86± 1.05%) than NPR ofBg406 variety (38.54± 1.07%). CFTRI Price of both varieties had highest HRY (71.35±1.26%) among rice parboiled by different methods. CFTRIP and DRP are suitable parboiling methods to get high percentage of head rice with short soaking duration.

Keywords: Milling yield, Parboiling, Rice, Soaking time.

Effect of ion (NaCl) interaction on resistant starch content of selected cooked tubers

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Resistant Starch (RS) is a type of bioactive compounds attracting consumer's interest, especially those at risk of diabetes, obesity and other related health problems. A study was conducted to find out the effect of ion (NaCl) interaction on resistant starch content of selected cooked tubers such as potato (*Solanum tuberosum),* cassava (*Manihot esculenta)* and elephant foot yam (*Amorphophallus paeoniifolius),* which were commonly consumed in Jaffna, Sri Lanka. Initially preliminary trials were conducted to find out the optimum temperature, time and salt (NaCl) content during conventional cooking for the selected tubers. Then tubers were cooked with and without salt under optimum conditions (100 ^{O}C, 15 minutes and 2% salt) and their resistant starch and nonresistant starch content were measured using standard enzyme hydrolysis method using α-amylase and amyloglucosidase. Results of the above study revealed that resistant starch content of selected raw tubers was significantly ($p>0.05$) higher than their respective cooked tubers. Resistant starch content of potato, cassava and elephant foot yam samples cooked without salt were 5.58±0.23, 4.13±0.27 and 5.89±0.36g/100g dry sample respectively and the respective tubers cooked with salt were 6.07±0.50, 3.78±0.22 and 4.93±0.09 g/100g dry sample. Ion (salt) interaction has increased the resistant starch content in cooked potato and decreased the content in cooked cassava and elephant foot yam. There are no significant differences ($p>0.05$) on the resistant starch content of potato and cassava cooked with salt and without salt. But the resistant starch content of the elephant foot yam cooked without salt was significantly ($p>0.05$) higher than respective samples cooked with salt. Therefore higher level of resistant starch content of the cooked tubers can be maintained by adding minimum level of salt.

Keywords: Cooked tubers, Ion interaction, Resistant starch, Salt.

Determination of Metanil yellow in Chili and Turmeric powder samples available in Jaffna peninsula

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Metanil yellow ($C_{18}H_{14}N_3NaO_3S$) is a synthetic azo dye, not permitted to use in food products in many countries because of their potential carcinogenicity. But they are illegally used to colour food products like turmeric powder and chili powder due to their lower prices. The purpose of this study is to find out the possibility of usage of Metanil yellow in commercial turmeric powder and chili powder samples available in Jaffna peninsula. A total of 48 samples including 28 chili powder and 20 turmeric powder samples were tested qualitatively and quantitatively for the presence of Metanil yellow. All the 48 samples were tested were negative for the qualitative examination of Metanil yellow. A spectrophotometric method was developed for the quantitative determination of Metanil yellow. The point of maximum absorption was selected as 450 nm for this method by a wavelength scanned from 300-600 nm. Centrifuge pretreatment at 5000 rpm for 20 minutes was suitable to reduce the problem of particle interference during absorption measurement. Limit of detection (LOD) and the limit of quantification (LOQ) of the experiment were 0.4653 and 1.41µg /ml, respectively. This experiment exhibited a good accuracy with a percent of recovery (R %) of 95.74%. In the quantitative estimation the Metanil yellow content of all 48 samples were found below the level of limit of detection (LOD) of 0.4653 µg /ml. Based on the results of this experiment all the chili and turmeric powder samples tested were not contained non permitted colour Metanil yellow. Therefore they are safe for consumption.

Keywords: Chili powder, Jaffna peninsula, Metanil yellow, Turmeric powder.

Comparative studies on functional properties of Palmyrah seed shoot flour with Wheat and Rice flour

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Palmyrah palm (*Borassus flabellifer*) produces two types of flour such as *odiyal* and *pulukodiyal* flour. *Odiyal* flour obtained from sundried ground seed shoot of palmyrah though boiled dried and ground tuber give rise to *pulukodiyal* flour. Rice and wheat flour with different functional properties yield products with different textural qualities. If this palmyrah flour has appropriate functional properties it must be selected as a raw material to produce products, such as desserts and noodles. Therefore the present study was carried out to compare the functional properties of different flour, that is, wheat flour (PRIMA), rice flour (ANNA) and palmyrah flour such as *odiyal* and *pulukodiyal* flour. The functional properties (Water absorption capacity, Oil absorption capacity, Foam capacity and foam stability, Bulk density, Swelling capacity and Least Gelation Concentration) and moisture content of flours were evaluated. Wheat flour (4.34%) and rice flour (11.52%) showed significantly ($p<0.05$) lowest and highest moisture content respectively when compared with other flour. *Odiyal* flour has significantly higher values for Oil absorption capacity (93.33%) and Foam capacity (40.64%) while *pulukodiyal* flour showed highest values for Water absorption capacity (320%), Bulk density (0.79g/cm^3) and Swelling capacity (29.00%). Wheat flour was showed highest value for least gelation concentration while rice flour showed lowest value compared to palmyrah flour. Palmyrah flour have good functional properties compare to wheat and rice flour which enhance the functional ingredients of food products also has a lot of potential in the food industry as thickening agent for desserts preparation in the food systems.

Keywords: Functional properties, Palmyrah, Shoot flour.

Development and Investigation of Garlic Added Yoghurt Using Cow Milk

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Yogurt has greater popularity among fermented milk products. The development of fruit and flavoured yoghurt resulted in this product becoming of major importance in markets. Garlic is a common food spice and herbal medicine for preventing of many human diseases. Therefore a study was conducted to analysis physico- chemical properties of yogurt by incorporating of garlic paste at different concentrations. Yoghurt mixtures were prepared with 0.5%, 1%, 2%, and 3%, and without garlic paste. They were subjected into chemical, sensorial and microbial assessment during the storage period of four weeks. At first week, the chemical attributes such as ash, dry matter, total sugar, reducing sugar and pH show significantly ($p<0.05$) higher in 3% garlic added yoghurt. On the other hand, titrable acidity was higher in yoghurt made without garlic paste. At fourth week of storage period garlic (3%) added yoghurt received higher mean value for ash, dry matter, total sugar, reducing sugar and pH. Similarly yoghurt made without garlic received higher mean value for titrable acidity. Garlic reduced the bacterial load in the yoghurt as bacterial count was decreased with increase in the concentration of garlic paste. Finally, organoleptic assessment was revealed that there were ($p < 0.05$) changes among the treatments in the sensory attributes. Although, yoghurt made from 1% of garlic at first week of storage showed the best overall acceptability compared with other all treatments, which contained values of ash, dry matter, total sugar and reducing sugar were 0.61±0.05%, 14.73±3%, 12.7 ±1.57% and 1.86±0.19%, respectively.

Keywords: Garlic, Nutritional quality, Overall acceptability, Yoghurt.

Assessment of lead and cadmium levels in selected soils of Jaffna District of Sri Lanka

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Cadmium (Cd) and lead (Pb) are hazardous metals which can cause deleterious health effects when consumed above safe limits. These two cations could enter the human body through plant based food for which soil is the major contributor. The main source of Cd in soils is suspected to be phosphorus fertilizers while emission from vehicles via fossil fuel burning is the major source for Pb. A study was conducted to assess the total and available Cd and Pb in soils from different land use system in Jaffna. Soil samples were collected from up land/low lands of cultivated and uncultivated soils. Design was complete randomized design in a three factor factorial with three replicates. The total Cd and Pb and available Cd and Pb in the soils were determined. In addition other soil properties such as total organic carbon (TOC), microbial biomass carbon (MBC), water soluble carbon (WSC), and permanganate oxidizable carbon (POC) were also measured. Total Cd and available Cd were not in the detectable limits by the Atomic absorption spectrophotometer. As the lowest detectable limit is 0.02 ppm they were below 0.02 ppm in soils from Jaffna district. The total Pb and available Pb ranged between 0.81 to 26.41 ppm and 0.428 to 13.808 ppm respectively (The European Community set standard values for maximum permissible level of soil Pb is 150–300 ppm). Total Pb and available Pb did not show any significant difference with soils, elevation, land-use and depth. Total Pb and available Pb showed high negative correlation with distance from main road in both districts. Both total and available Pb showed weak negative correlations with TOC and water soluble carbon whereas both total and available Pb showed significant negative correlation at 95% confidence level with MBC.

Keywords: Cadmium, Carbon fractions, Lead, Soils.

Formulation and quality assessment of compost prepared with different compositions of Palmyrah resources

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A study was carried out to find the best formulation for compost by utilizing palmyrah resources and to study the effect of such compost on crop yield. This study was done at Palmyrah Research Institute. The experiment was designed in a Complete Randomized Design with seven treatments and three replicates. Palmyrah leaf, Palmyrah coir dust, paddy straw, cow dung and commercial compost were used as raw materials for the study. Palmyrah leaf (L) and Palmyrah coir dust(C) were mixed in different ratio while maintaining other raw materials in same percentage each for all treatments. T_1(L:C 0:60), T_2(L:C 10:50), T_3(L:C 20:40), T_4(L:C 30:30), T_5(L:C 40:20) , T_6(L:C 50:10) and T_7(L:C 60:0). Cow dung, paddy straw and commercial compost were added in 30%, 5% and 5% respectively. A pot experiment was done under green house with the test crop of Okra (*Abelmochus esculentus*). Four months after formulation different types of compost were applied to test crop and quality of compost was tested according to SLS 1246: 2003. Results were analyzed in SAS software and the mean separation was done by LSD at p=0.05. All seven composts have met minimum requirement of carbon and nitrogen content.T_7 exceeded the limit of C: N ratio and also did not meet the minimum requirement of phosphorous content. Other six treatments obey to SLS in C: N ratio (10 to 25).T_3 and T_5 did not meet the minimum requirement of phosphorous and magnesium (0.5%), respectively. T_1 also had lower phosphorous content than the minimum limit of SLS (0.5%). T_4 and T_6 did not meet the requirement of magnesium content. Results of the pot experiment revealed that treatment T_2 has given higher crop yield. According to the crop response nutrient composition T_2 was identified as the best compost formulation.

Keywords: Coir dust, Compost**,** Palmyrah.

Morphological and Agronomical diversity present in popular cluster onion (*Allium cepa.l.*) L and races in Northern region of Sri Lanka

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There are three major groups of cultivars available in Jaffna district; *Jaffna local*, *Vallarai* and V*ethalam*. Twenty characters were studied for twenty six germplasm of these groups collected from Jaffna district. Of which plant height, leaf width, bulb shape, size, maturity group, TSS and yield potential varied among them. Maturity day was the powerful tool to separate different germplasm according to their group as sort, intermediate and long day groups. Leaf colour and bulb skin colour also had significant differences. *Peeranki vethalam* (013/Ac/Jc/20) had highest plant height (26.66 cm), widest leaf (0.58 cm), more number of leaves per plant, highest single plant weight (39.96 g), heaviest bulb (6.68 g) with more breadth (2.27 cm) and highest yield (18 tons/ha). Multipliers were taller plant with wider, more number of leaves than shallots and they attained heavier plant with heavier bulb, which lead to high yields. Colour difference, in RHS clour chart, in leaf and flesh were contrast among three majour groups. *Kalvethalam* had significantly lighter colour skin and bulb flesh colour than that of other germplasms Among shallot *Thinnavely red*, a newly improved variety, natural mutation from from Jaffna local differed by its dark colour bulb skin. Shallots (*Jaffna local* and *Vallarai*) had relatively more cluster than multipliers and had greater per day productivity. *Kalvethalam* had relatively lower per day productivity within multipliers. According to maturity period, germplasms were classified as short age group (<60 days), medium age group (60-70 days), long age group (>70 days), *Jaffna local*, *Vallarai* and *vethalam* respectively. Therefore this study concluded three major types of germplasms, had three different maturity durations and the yield potential. Flowering efficiency varied widely with the range from 01-65 %. Ample diversity has been confirmed among the tested entries.

Keywords: Characterization, Cluster onion, Landraces.

Effect of graded levels of nitrogen on plant height and flower yield of Jasmine (*Jasminum sambac* L.) cv. Local in the Batticaloa district

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An experiment was carried out to evaluate the effects of graded nitrogen levels on plant height and flower yield of Jasmine (*Jasminum sambac* L.) cv. Local in Batticaloa district. Graded levels of nitrogen were defined as treatments viz. 0 (T1), 50 (T2), 100 (T3), 200 (T4), 300 (T5), and 400 (T6) g of nitrogen/plant/year. Nitrogen was applied at monthly interval. Phosphorous and potassium levels were be kept constant throughout the experiment and applied as basal dressing. The experiment was arranged in a completely randomized design with three replications. Agronomic practices were followed uniformly for all treatments. Plant height and flower yield were measured at monthly interval. Analysis of Variance was performed to determine significant difference among treatments ($p < 0.05$). Results indicated that plant height and flower yield were significantly higher in T4. Plants grown at this nitrogen level would have received optimum amount of nitrogen. Therefore growth and flower production of Jasmine was higher at this treatment. From this experiment, it could be stated that nitrogen level of 200 g/plant/year is optimum for growing Jasmine in dry zone since growth and flower yield were higher.

Keywords: Flower yield, Jasmine, Nitrogen level, Plant height.

Coir dust extract as a cost effective culture medium in multiplication of *Bacillus thuringiensis* against *Aedes aegypti*

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Aedes aegypti is the principal vector for dengue disease. During the last 9 months of the year 2015, 20823 suspected dengue cases have been reported from all over the Sri Lanka. *Bacillus thuringiensis* (*Bt*) *is* widely used in mosquito control programs. However, the large-scale multiplication of this *Bt* is expensive due to the use of high cost of the production medium. In this study coir dust extract which locally available raw material that coir dust from the coir fiber industry was selected as a medium for small scale culturing of *Bt* was used to develop a cost-effective medium and it was tested against last instar larvae of *A. aegypti* using the concentration of 20, 30, 40, 40, 60, 70 mL/L. The larval mortality was assessed after 24 and 48h. Experiments were designed in a Complete Randomized Design and obtained data were statistically analyzed using SAS package 8.0. Lethal concentration (LC_{50}) value was estimated by probit regression analysis. *Bt* at 70mL/L excelled to cause 77.5% and 92.5% mortality of larvae at 24 and 48 h after the application, respectively. LC_{50} of 53mL/L on 48 h of exposure was obtained against fourth instar larvae of *A. aegypti* using a 72 h old culture grown in coir dust. Hence, coir dust extract based culture medium is suitable for the multiplication of *Bt* for controlling *A. aegypti*

Keywords: *Aedes aegypti*, *Bacillus thuringiensis*, Coir dust extract, Lethal concentration, Mortality.

Screening of salinity tolerant rice cultivars at seedling stage

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Rice is the staple food for more than a billion people worldwide, which includes twenty million people in Sri Lanka. Currently about 100,000 hectares of paddy lands in Sri Lanka are affected by salinity which limiting the crop production in worldwide. Therefore selection of rice cultivars which are tolerant to salinity is an important requirement for paddy cultivation in Sri Lanka too. In this study fifteen rice cultivars *Masuran, Poththalai, Kahamala, Puspharaga, Heteda wee, Beheth heenati, Rathkandu, Suwandel, Dickwee, Kahawanu, Weeda heenati, Kirinaran, Rath suwandel, Rathdel and Godaheenati* were collected from the Anuradhapura district to screen the salinity tolerant rice cultivars. To fix the treatments, soil samples were collected from different places in Jaffna district and the highest salinity 154µs/cm and lowest salinity 51.6µs/cm were recorded by using electrical conductivity meter. The salinity range was selected from 50 -155 µs/cm. From this preliminary study, five treatments 0, 50, 85, 120 and 155 µs/cm were selected and maintained by adding different concentration of salt solution in sixty pots. Seed germination percentage under different treatments and seedling height, shoot length, flag leaf width, flag leaf length were measured at 20, 25, 30, 35 and 40 days after planting. Complete randomized design was used to analyze the agronomic characters of cultivars and the mean was separated by DMRT. All the results were analyzed by using SAS statistical package, version 8.0. Germination percentage of the tested rice cultivars were not significantly different from the control at all salinity levels tested in this experiment except *Behetheenati* and *Dickwee* cultivars. Flag leaf length and girth length of all cultivars increased with increasing salt level. Plant height

and root length of all cultivars reduced with increasing salt level. Germination, root growth, shoot growth of all rice cultivars tested were not significantly different at 50µs/cm and were significantly lower at 120µs/cm and above salt level from the control. *Poththalai* shoot and *Godaheenati* root development were significantly higher than other cultivars at all salinity levels tested. *Beheththeenati* and *Dickwee* cultivars had poor performance in tested agronomic characters and were susceptible even at 50µs/cm salt level. Agronomic characters of *Godaheenati* were significantly higher and this cultivar performed well even in 155 µs/cm salt level and is the best salinity tolerant cultivar among the tested cultivars.

Keywords: *Godaheenati*, Jaffna, Rice, Salinity, Salt concentration.

Lactation Curves Modeling of Nili Ravi and Nili Ravi crosses in the Intermediate Zone of Sri Lanka

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Lactation curve of an animal can be expressed as a mathematical model that explains the relevant general pattern of milk production throughout the lactation. A study was conducted to find out the best fit model for the lactation curves of Nili Ravi buffaloes and Nili Ravi crosses in the Intermediate Zone of Sri Lanka. Data on daily milk yield from Nili Ravi buffaloes (n=7071 records) and Nili Ravi crosses (n=17640 records) for the period of 2007-2013 were obtained from the National Livestock Development Board farm, Melsiripura located in the Intermediate Zone of Sri Lanka. The mathematical models proposed by Wood, Cobby and Le Du, Exponential, and Parabolic Exponential were fitted using nonlinear regression procedures in SAS 9.0. The best fit model was identified using the highest coefficient of determination (R^2) and the least mean square error (MSE). The estimated R^2 and MSE values of Nili Ravi for the models of Wood, Cobby and Le Du, Exponential and Parabolic exponential were 0.8018 and 0.4451, 0.8006 and 0.4464, 0.7951 and 0.4526, and 0.7975 and 0.4499, respectively. Whereas, for the Nili Ravi crosses the estimated R^2 and MSE values were 0.8243 and 0.4192, 0.8198 and 0.4244, 0.8150 and 0.4301, and 0.8174 and 0.4273, respectively. All four models provided satisfactory fits with high R^2 (>0.75) and low MSE values for both genotypes. With the highest R^2 and lowest MSE values, Wood's model ($Y_t = at^b \exp(-ct)$ where, Y_t is milk yield on t^{th} day of lactation) could be recommended for modeling lactation curves of both genotypes with estimates for a, b and c model parameters being 4.8355, 0.1736, and 0.005, respectively for Nili Ravi buffaloes and 4.1647 , 0.2044, and 0.006, respectively for Nili Ravi crosses .

Keywords: Buffaloes, Lactation curve, Modeling, Nili Ravi, Wood's model.

Growth conditions of Teak (*Tectona grandis* L.) Plantation in Mullaitivu District

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Teak is an important timber plant widely used in Sri Lanka. Teak plantation was established in Northern part of Sri Lanka since 1960's. Among the districts of the Northern region, Mullaitivu is a potential district for teak plantation. There were no scientific studies done regarding teak plantation and its distribution pattern in Northern region. Therefore, a study was carried out to assess the distribution patterns and estimate the above ground biomass in Mullaitivu district during the period of February to May, 2015. Plant height, diameter, crown height and canopy diameter were measured from selected teak plants in four locations such as Mulliyawalai, Mankulam, Karripatammuripu and Theravil. The measurements were taken with square plot size of 15 m × 15 m and found that the Mulliyawalai and Theravil sites had same aged plantation of 22 years. The highest average height and dbh value had observed in Theravil site as 19.80±0.28 m and 20.10±0.24 cm, respectively. The highest aboveground biomass of 410.37 t/ha and tree volume of 579.58 m^3/ha was found in Mulliyawalai. Among the four locations, the highest average above ground biomass (1,301.49 t/ha) and tree volume (2,043.77 m^3/ha) were observed in Karripatammuripu plantation. From this study Theravil site was selected as the best site for planting of teak. To confirm these findings, detail studies needs to be carried out on different parameters.

Keywords: Aboveground biomass, Diameter-height-volume, Distribution, Plantation forest, Mullaitivu.

Plant Diversity and Income Generation of Home garden in Kilinochchi District

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Home gardens are considered as one of the sustainable land use systems in Sri Lanka. Sustainable production and enhance the socio-economic condition can be achieved by home gardening. There were no data regarding the available species density and involvement of home garden in food and nutrition supply in Kilinochchi district. The district comes under DL3 agro-ecological zone. The study was carried out in three Divisional Secretariat (DS) divisions as proportion of number of Grama-Niladhari(GN) divisions to estimate diversity of plant species contribution of home garden in food and nutrient supply. Total of 150 households were investigated using structured questionnaires. Data were analyzed by using excel spread sheet and Minitab 2014 and statistical analysis of variance also done. The result of this study shows the fulfillment of needs of households in study area partially achieved by production from their own homegardens. High species density was observed in the areas where sufficient water is available. Average income (73,756±225) from household was not linearly linked with average size of home garden (0.35±0.0019). Annual crop such as vegetables (35%) play a greater role in income generation compare with perennials. Mayavanoor Grama Niladhari division found to be as leading one for having highest percentage of farmers for coconut (93%), banana (73%), and mango (47%). The highest plant species diversity (1108) was found in Ambalnagar Grama-Niladhari division by having more economically important species. The best home garden was identified by having animal husbandry in small or in large scale. Farmers faced the problems

of lack of water availability, climate uncertainty and market failure in their cultivation. Even though better choice of crops and different land use patterns adopted make them survive and sustain with their production.

Keywords: Home garden, Income contribution, Species distribution.

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